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A PRACTICAL TREATISE

ON

DYEING AND CALICO-PRINTING;

INCLUDING THE

LATEST INVENTIONS AND IMPROVEMENTS;

ALSO

A DESCRIPTION OF THE ORIGIN, MANUFACTURE, USES, AND CHEMICAL PROPERTIES OF THE VARIOUS ANIMAL, VEGETABLE, AND MINERAL SUBSTANCES EMPLOYED IN THESE ARTS.

WITH AN APPENDIX,

COMPRISING DEFINITIONS OF CHEMICAL TERMS; WITH TABLES OF WEIGHTS MEASURES, THERMOMETERS, HYDROMETERS, &c.

BY AN EXPERIENCED DYER.

ASSISTED BY

SEVERAL SCIENTIFIC GENTLEMEN.

Edward Aaron Parnell

WITH ENGRAVINGS ON STEEL AND WOOD.

NEW YORK:

HARPER & BROTHERS, PUBLISHERS,

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TO THE DYERS,

CALICO-PRINTERS, BLEACHERS, MANUFACTURING

CHEMISTS, AND OTHERS CONCERNED

IN THE KINDRED ARTS,

THIS VOLUME

IS RESPECTFULLY INSCRIBED.

PREFACE.

EXPERIENCE is the great fountain of knowledge. Although mankind are indebted to the deductions of abstract Science and the intuitions of Genius for many valuable discoveries in the domain of the Useful Arts, yet it is not the less true that the march of invention and improvement in the practical pursuits of life has usually been a steady, gradual, step by step progress. Ages before Lord Bacon enunciated the axiom that education is the only true and sure key to the treasure house of Nature's secrets, the leaders and pioneers in the great work of industrial advancement had made that truth the basis of their efforts, and acted in undoubting conviction of its soundness. In order to govern and guide the impetuous and apparently wayward combinations of matter, they were content to learn as children, and follow trustingly as devotees. Only thus will Nature consent to place her gigantic and wondrous laboratories at the disposal and service of our race. Wisely, shrewdly, therefore, have practical men regarded with habitual distrust the promises of sciolists and empirics, to open to them royal roads to the results they would compass, by following, usually at heavy cost, certain abstractions which they term infallible deductions from the laws of Chemical Affinity. For, though the laws of matter are indeed immutable, and their operation perfect, our knowledge even of the least recondite and most important among them is very often far otherwise.

We know that certain phenomena apparently stand to each other in the relation of Cause and Effect; but if we would act, in any matter of importance, on the assumption that cer-

tain other phenomena must stand in like relation, we should begin by subjecting our theory to the ordeal of Experiment. Doubt, of whatever kind, is to be dispelled by Action alone.

But the error of trusting too far to theory, with the misfortunes which it has engendered, has often impelled practical men of limited acquirements to the opposite mistake of condemning all book-making, (so they term it,) as illusory or at least superfluous. They say truly that Experience is the only safe guide in the Useful Arts; but the conclusion they virtually arrive at implies that *their* experience of itself is all sufficient. They might as well assume to evolve the whole science of Geology from the analysis of a single field or stone-heap. The fact that their own observation and that of their predecessors has proved rich in suggestions of improvement should have taught them rather to appreciate than to disregard the combined and infinitely varied experience of all who have at any time been engaged in the same or subsidiary avocations. Here, then, is the proper sphere of a practical treatise on any branch or branches of the Useful Arts. By it the knowledge which has been obtained through a long series of experiments at a cost of thousands, and often at the hazard of personal injury, is made available to all who may seek it at a trifling expense, and without inconvenience or danger.

Perhaps there is no department of industry to which these remarks apply with greater force than to the art of *Dyeing*, connected as it is on one side with the most subtle and profound speculations in Natural Philosophy, on the other with the every-day practice of many useful arts. It is not and must not be regarded as an isolated pursuit, which can be carried to perfection by itself. Its improvement must closely follow the march of the Physical Sciences, and will ever be intimately interwoven with the advancement of several other arts.

Dyeing, therefore, is manifestly a *progressive* art—a trade that must be learned, and one which equally with any other, is dependent for its successful prosecution on a clear understanding of principles. Those engaged in it have equal need and equal claim with any other class of artists to be supplied

with all the information which may be rendered conducive to their interest, and to their perfection in their calling. The delicate and critical character of many operations in their art renders precise and certain information in regard to the necessary processes of more importance in theirs than in almost any other avocation.

The trade of the dyer is open and accessible to all, and some of its simpler details are acquired with decided facility; consequently, the instances are rare in which young men attain a thorough knowledge of the art through a regular apprenticeship or systematic course of instruction. Dyers have usually become such at a mature age, and the summit of their ambition has been to acquire a ready familiarity with, and expertness in, the mechanical routine of the dye-house and print-work; and when these are secured, with the highest attainable rate of wages, their zeal for improvement subsides. A few, indeed, not content with the honors, or perhaps with the wages, of journeymen, aspire to a foremanship; but the path whereby they hope to climb to such preferment is simply that of long and steady service, and a good memory for manipulation. These are valuable qualifications, but they would be in no degree depreciated by adding to them a more extended and thorough knowledge of the fundamental principles of the art than usually falls to the share of the practical dyer. And not only is the amount of such knowledge usually possessed insufficient, but there is manifested in the dye-house a palpable and lamentable lack of interest in every thing regarding the ordinary round of mere mechanical operations.

Dyers who achieve the distinction of good workmen are accustomed to estimate their abilities by the contrast which exists between themselves and the newly initiated journeyman; they rarely or never contemplate the wide field which lies unimproved if not unexplored before them. Indeed some of them are so injudicious as to boast of their capabilities, their expertness and their knowledge; and it is not uncommon for such to indulge in petty jealousies, and to endeavor to conceal the *secret* of their mode of producing a certain

result. Follies of this sort have not been confined to journeymen; an employer has been known to complain that his workmen are inefficient, when at the same time he was stealing, as it were, from one part of the dye-house to another with the very materials which it is their business to understand and use, in covered vessels, lest some one should learn what is the nature of the process whereby he produces, through their labor, a desired result. He thus exacts of them the advantages of knowledge, while doing his best to retain them in ignorance. While such narrow views are prevalent we may regret, but cannot wonder, that years have been spent—we should rather say wasted—in persevering and costly efforts to discover *what was long before well known to all who thoroughly understood the scientific principles of the art.* This same ignorance of principles often renders both masters and workmen the dupes of a class of impudent knaves who hawk about *valuable secrets* at so much apiece.

Although chemistry is making rapid and constant advances, many of the useful arts dependent on that science are stationary; the artisans or manufacturers interested therein being too imperfectly acquainted with Chemical Science to profit by the hints so frequently afforded them, or even to know in what direction to look for improvements. By this negligence or inability of the practical man, Scientific Chemistry is in turn greatly retarded. And yet, in defiance of all untoward influences, the recent progress of our art has been truly astonishing. A single practical hint has often sufficed to work a complete revolution in some branch of the trade; and were the principles of Chemistry once generally understood by those practically engaged in their application to Dyeing, we can hardly fix a limit to the changes and improvements which would ensue. Lord Bacon's axiom, that 'knowledge is power!' though trite, is still profoundly true, and nowhere else is its truth more emphatically demonstrated than in the domain of the practical dyer.

The only treatise on Dyeing extant that deserves consideration is, we need hardly say, that of Berthollet. Dr. Bancroft's work ranks next, but it is of little or no use in the dye-house,

being too exclusively theoretical, at the same time that it is immethodical, and full of inexcusable repetitions. It is a complete wilderness of words, often without definite meaning or the least applicability to the subject in hand. It is, in short —as practical men well know—better calculated to mislead than to instruct.

Berthollet's work, though superior to that of Bancroft, is yet of little value at the present day as a manual for the dye-house. Its directions are entirely too general, its conclusions are often exceedingly erroneous, and it is lumbered with useless repetitions and exploded theories.

Neither of these publications, however, contains a solitary improvement, made since 1814, in any of the processes of which they treat, so that nine-tenths or more of their contents have been utterly superseded by discoveries and improvements made since they were written. No other book on dyeing has appeared that even aspires to be original and practical.* In the following treatise the author has endeavored—

1. To reduce the whole theory of dyeing to the utmost simplicity and accuracy;

2. To classify, arrange, and define colors, in order to enable those who are pursuing the related branches of study, as well as the artist, to comprehend more easily the nature of each particular hue, tint, and shade, and the relation it bears to the primary elements of light, darkness, and color;

3. To elucidate each particular subject in such a manner as, it is hoped, will impart substantial knowledge to those seeking it, and at the same time exhibit those shoals toward which so many have been attracted by erroneous deductions and false conclusions;

4. To set forth the *actual* properties, characters, and uses of the various Animal, Vegetable, and Mineral substances employed in dyeing and the auxiliary arts; and

5. To define the various chemical and technical terms employed in the dye-house, print-work, &c.

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* Mr. Cooper's treatise is almost a *verbatim* copy of Berthollet's. It was published by Dobson, Philadelphia, 1814.

In the work which the author now presents to the public, he has embodied not only the results of his own experience, for more than twenty years, in the most celebrated dye-houses of Great Britain and France, but also a digest of all worth preserving *that has hitherto been written on the subject*, including everything of practical value to be found in Persozs' "Traité Théorique et Pratique de l'Impression des Tissus," "Annales de Chimie et de Physique," Ure's "Dictionary of Arts, Manufactures and Mines," his "Dictionary of Chemistry," and in Parnell's "Applied Chemistry." Giving others full credit for what they have done, the author has reserved and exercised the right of making such corrections and additions as his own practical experience has suggested, and the interests of the trade imperatively demanded.

In pursuing his investigations, the author enjoyed some advantages which few, if any, beside him, have ever possessed. Being intimately acquainted with nearly every leading manufacturer in England, France, Belgium, and Prussia, he has had free and full access to establishments which have been open to but few. He takes this opportunity to return heartfelt thanks for the kindness every where shown him, and trusts that it has been at least partially requited by the compilation of this work.

A brief description of every valuable invention and improvement connected with Dyeing or Calico-Printing made in Europe since 1834, is given in the following pages. Many of these inventions have proved of immense value to the trade, and the list, we are sure, forms one of the most important features of the work. To those of our brethren who care to institute comparisons between this and the works on kindred themes already in their hands, we would instance, as subjects for critical examination, the articles on *Indigo*, *Logwood*, *Madder*, *Bleaching*, *Mordants*, *Tannin*, and *Gallic Acid*, *Yellow*, *Blue*, &c., commencing on pages 72, 98, 105, 194, 247, 283, 324, and 331 respectively.

Practical men will hardly fail to observe that the general arrangement and classification of the subjects here treated, are based on principles entirely different from those which have governed the compilation of any former work on Dyeing

or Dyeing and Calico-Printing. They will also judge whether any other arrangement than that we have adopted would not have marred the utility and completeness of the work.*

In describing the various processes of dyeing, the author has endeavored, on every fitting occasion, to impress upon the operators the necessity of studying and understanding principles, in connection with his practice, and he has spared no effort to render his directions as lucid and simple as possible. If his observations shall have the effect of inducing even one of his brethren to attend more carefully to the principles of his trade, it cannot be said that his labor has been altogether in vain.

He cannot close these introductory remarks without tendering his grateful acknowledgments for the valuable aid he has received in the preparation of this work from Walter Crum, Esq., of Thornliebank, Glasgow, D. R. Hay, Esq., of Edinburgh, John Mercer, Esq., of Oakenshaw, James Thomson, Esq., of Primrose, near Clitheroe, and M. Daniel Kœchlin Schouch, of Mulhausen. Far distant be the day when genius, integrity, and enlightened philanthropy like theirs shall be divorced from that influence and honor which in such hands are wielded but to relieve the wants and increase the happiness of their fellow men.

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* A more detailed and accurate view of the plan of this work may be obtained by a glance over the table of contents, and also at the index.

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—Ligneous matter—Litre—Lixiviation—Maceration—Manganese—Manipulation—Measure—Mother Water—Muriate of Ammonia—Muriates of Tin—Muriate of Zinc—Naphtha—Neutralization—Neutral Salts—Nitrates—Oil of Turpentine—Oleic Acid—Ox-gall—Oxidation, or Oxidizement—Oxide—Padding—Perchloride of Tin—Peroxide of Iron—Peroxide of Tin—Potash, or Potassa—Potter's Clay, or Plastic Clay—Precipitate—Precipitation—Protoxide of Copper—Protoxide of Iron—Protoxide Tin—Putrefaction—Prussian Blue—Pyrometer—Red Liquor—Sal Ammoniac—Salop—Salt—Salt, Microcosmic—Salt of Lemons—Salt of Saturn—Salt of Soda—Salt of Sorrel—Salt of Tarter—Salt of Vitriol—Salt of Perlate—Saltpetre—Saturation—Scheele's Green—Silicates—Soap—Soda—Specific Gravity—Starch—Steatite—Sublimation—Subsalt—Sulphates—Sulphate of Alumina and Potassa—Sulphate of Ammonia—Sulphate of Copper—Sulphate of Iron—Sulphate of Lead—Sulphate of Magnesia—Sulphate of Manganese—Sulphate of Mercury—Sulphate of Potash—Sulphate of Soda—Sulphate of Zinc—Sulphites—Sulphur—Sulphuration—Tannin—Tartar—Thermometer—Tartrate of Potash—Troy weight—Turpentine, Oil of—Ultramarine—Vapor—Verdigris—Vermilion—Water of Crystallization—Weight. - 601

A

PRACTICAL TREATISE ON THE ARTS

OF

DYEING AND CALICO-PRINTING.

PART FIRST.

CHAPTER I.

HISTORICAL AND GENERAL REMARKS.

Colors of the Vegetable Kingdom—Origin of Dyeing—Celebrity of the Purple, Scarlet, and Blue Dyes of the Ancient Egyptians, Tyrians, and Israelites—Homer and Ovid's mention of Purple Garments—Varieties of Purple, and Processes of Dyeing them, described by Goguet and Heeren—Pliny's account of Purple Robes—Swinburne's description of the Purple Dye—Scarlet (of the Scriptures), probable method of Dyeing it in the time of Moses—Antiquity of Adrianople Red—Topical Dyeing of the Ancient Egyptians and Phœnicians, and Indians—Block-Printing in China—Origin of Calico-Printing—Dyeing by the Mexicans.

THE study of *the true, the good,* and *the beautiful,* has formed an important occupation of life in all highly civilized nations, and has been inculcated by the truest patriots and the highest philanthropists. Science, virtue, and beauty, form the noblest elements of creation, and of the human soul—they form the first objects of our national institutions, the highest elements of a national character, and the best themes of a national literature.

Amongst the various phenomena of nature, there is not one that more excites our admiration, or imparts a more vivid impression of the order, variety, and harmonious beauty of the creation, than that of color. On the general landscape this

phenomenon is displayed in the production of that chromatic beauty in which the elements of color are so variously and harmoniously blended, and in which they are by, light, shade, and distance, modified in such an infinity of gradation and hue. Although genius is continually struggling with but partial success to imitate those effects, yet, through the Divine beneficence, all whose organs of sight are in an ordinary degree of perfection can appreciate and enjoy them. In winter this pleasure is often to a certain extent withdrawn, while the colorless snow alone clothes the surface of the earth; but this is only a pause in the general harmony, which, as the spring returns, addresses itself the more pleasingly to our perception in its vernal melody: this, again, gradually resolving itself into the full rich tones of luxuriant beauty exhibited in the foliage and flowers of summer, which subsequently rise into the more vivid and powerful harmonies of autumn's coloring, prepares the eye again to enjoy that rest which such exciting causes may be said to have rendered necessary.

When we pass from the general coloring of nature to that of particular objects, we are again rapt in wonder and admiration by the beauty and harmony which so constantly and in such infinite variety present themselves to our view, and which are so often found combined in the most minute objects. But the systematic order and uniformity perceptible amidst this endless variety in the coloring of animate and inanimate nature, is another characteristic of beauty equally prevalent throughout the creation.

To imitate nature in this profusion of beauty, is and has been the pride of man in all ages, and in all ranks and conditions of life. The desire of attracting public admiration may be observed even in the least civilized state of society. Among the means of distinction which are eagerly laid hold of, the glare of colors is one of the most obvious. The savage with whom clothing forms no object of ambition, tatoos and daubs his body with all the various colors his ingenuity can prepare; while the civilized man, by a process more refined, imparts the color to his clothing. From this passion of en-

deavoring to imitate nature in all that is beautiful, have sprung up the two kindred arts, *dyeing* and *painting*. Of the latter, the public have already the highest conceptions,—kings have taken it under their protection, and poets have sung its praises; but the former, though all enjoy its advantages, remains in comparative obscurity.

The art of dyeing has, as we shall endeavor to show, unquestionably a very ancient origin; for when nature afforded coloring substances of easy application, there might arise among people but slightly civilized, methods of dyeing which have been sought after by polished nations.

From the writings of Moses, it is obvious that the art of dyeing had in his time made great progress: it was certainly known in Jacob's time, as we find from Joseph's coat *of many colors*, and also from the scarlet thread which the midwife tied about the hand of one of Thamar's children. How much earlier this art was known, it is impossible to ascertain; its high antiquity, however, is easily accounted for. Most of the materials fit to be manufactured into tissues are of dull and sombre colors, and men would naturally seize the first hints that offered of obviating the unpleasant uniformity of the dress thus produced.

It is, perhaps, also equally probable, that in proportion as society advanced, and a division of labour became convenient, an improved knowledge was acquired, not only of spinning and weaving, but in that of breeding and selecting those animals, whether sheep or goats, which gave the finest of fleeces. We may imagine that in the earliest state of the *Woolen Manufacture*, when cloth was merely a substitute for the skins of beasts as an article of clothing, little attention was paid to the color or fineness of the wool; but as luxuries were introduced, colored garments were required, and the wool could no longer be taken from sheep of every kind, white, brown, or black. The grower, therefore, began to pay more particular attention to the whiteness and beauty of his fleece, which was essential to render the cloth susceptible of the brilliant dyes, and which, as we shall show, were given to it at a very remote period:—

Gen. xxxviii. 3. Now Israel loved Joseph more than all his children, because he was the son of his old age, and he made him a coat *of many colors*.

The value and distinction attached to such variegated dresses, shows that they were not common, and were formed by some elaborate process. This continued long after the time of David; such a dress was a distinction for a king's daughter, 2 Samuel, xiii. 18:—"And she had a garment *of divers colors* upon her, for with such robes were the king's daughters that were virgins apparaled;" and Judges v. 30:—"Have they not divided the prey; to Sisera a prey of divers colors of needlework on both sides, meet for the necks of them that take the spoil?" Here we see ladies anticipating the return of a victorious general, with a prey of divers colors of needlework on both sides. We may, therefore, infer that in those times people did not wear variegated dresses, the common use of which must have been consequent on the discovery of the art of dyeing, interweaving a variegated pattern in the original textures, or *of printing it subsequently*. Dr. Roberts states, that in India it is now customary to invest a beautiful or favorite child with a coat of many colors, consisting principally of crimson, purple, and other colors, which are often tastefully sewed together. He adds, "A child being clothed in a garment of many colors, it is believed that neither tongue nor evil spirit will injure him, because the attention is taken from the beauty of the person to that of the garment."

"In reading the following texts of Scripture," says Bischoff,* "it had frequently occurred to me, that the colors so named could not apply to fine linen, for if that were the case it would have been more clearly expressed, without the word 'and' preceding '*fine linen*,' viz: 'blue and purple and scarlet fine linen.' And in Exodus xxvi., the 'and' betwixt 'fine linen,' and the 'blue,' &c., makes a marked distinction betwixt them, so as to show that the color did not apply to the linen. This construction appeared the more probable, because the full lustre and beauty of the color cannot *now* be given to

* Bischoff's Treatise on the Woolen and Worsted Manufactures of Great Britain, vol. i. p. 17. London: Smith, Elder & Co.

vegetable materials, and consequently that part of the art of dyeing must have been lost. It therefore appears most probable, that as they could not mean 'linen,' they might or did mean woolen manufacture:—

Exod. xxv. 3. And this is the offering which ye shall take of them; gold, and silver, and brass,

4. And blue, and purple, and scarlet, and fine linen, and goats' hair.

Exod. xxvi. 1. Moreover thou shalt make the tabernacle with ten curtains of fine twined linen, and blue, and purple, and scarlet, &c.

Exod. xxviii. 6. And they shall make the ephod of gold, of blue, and of purple, of scarlet, and fine twined linen, with cunning work.

"With a view to ascertain this point," says Mr. B., "I applied to Professor Hurwitz, who sent me the following note:—

DEAR SIR,—In reply to your note, permit me to say, you are quite correct in your conjecture. Our most ancient commentators have been of the same opinion: the Talmud, Tarchi, Aben Ezra, &c. Mendlesohn, in his German translation, renders Exodus xxv. 4, 'Himmel blaue, purpur rothe, und hoch rothe *woolle;* und linen garn,' &c.; although strictly, speaking the Hebrew words תכלת—sky blue, ארגמן purple, and תולעת שני —designate only the colors. In the instance as cited, the word צמר—wool is understood:—

Numb. iv. 6. And shall put thereon the covering of badgers' skins, and shall spread over it *a cloth* wholly of blue, and shall put in the staves thereof.

7. And upon the table of the shew bread, they shall spread a cloth of blue, and put thereon the dishes, and the spoons, and the bowls, and covers to cover withal; and the continual bread shall be thereon.

8. And they shall spread upon them a cloth of scarlet, and cover the same with a covering of badgers' skins, and shall put in the staves thereof.

The word 'cloth' of our translation corresponds with the Hebrew בגד, *beged*, which means generally a garment, a cloth used for covering, made either of linen or wool; but in the present instance tradition tells us they were coverings made of wool, of the several colors mentioned in the text.

"The information thus given appears to establish the point as to the early woolen manufacture, and looking to the facility and simplicity with which that would be carried on, as compared with the linen manufacture, it is most probable that for a long period the woolen manufacture was the only one

known, and was indicated by the names of the colors alone. The same taste for colors still remains in the East, and the art of dyeing, which may have originated there, was carried to great perfection, having many of the dyeing materials produced there: the brilliancy of the colors is seen in the rich *carpets* of Persia and Turkey; and Mr. Fellows mentions their prevalence in the saddle-bags, carpets, and cushions, as worked of various hues, and made in the families of the shepherds."*

Tyre appears to have been the only city of antiquity which made dyeing its chief occupation, and the staple of its commerce. There is little doubt that purple, the sacred symbol of royal and sacerdotal dignity, was a color discovered in that city; and that it contributed in no small degree to its opulence and grandeur.

Goguet and Heeren have respectively brought much interesting information with regard to the purple of antiquity, and from their works the following particulars are chiefly drawn:

"The pre-eminence given at the present day to purple, as a royal color, is undoubtedly, a result of the ancient preference, which arose when the relative superiority of purple to other colors was greater than at present. We have seen the color frequently mentioned in connection with the works of the tabernacle and the dress of the High Priests: and among the heathen we know that the color was considered peculiarly appropriate to the service of the gods. The Babylonians and other nations used to array their gods in robes of purple. An opinion was even entertained that in the purple dye there lay some peculiar virtue for appeasing the wrath of the gods. Purple was also the distinguishing mark of great dignities among several nations. It is said that when the beautiful purple of Tyre was first discovered, the sovereign to whom it was presented appropriated it as a royal distinction. Homer intimates that it was worn only by princes, and that limita-

* Those who desire more copious information on these subjects, should consult the "Pastoral Life and Manufactures of the Ancients," notices of which work will be found at the end of this volume.

tion of its use was common with the nations. A very early notice of this occurs in Scripture, when the king of the Midians, defeated by Gideon, was described as being clothed in purple raiment. Judges, viii. 26, "And the weight of the gold ear-rings that he requested was a thousand and seven hundred shekels of gold, besides ornaments and collars and purple raiment, that was on the kings of the Midians." It seems to us very likely that there were several purples, held in various degrees of estimation: it was only some particular shade of purple that was reserved for a god-like or royal distinction.

It is, indeed, important to understand that the word purple in ancient writings does not denote one particular color. Pliny mentions the difference between some of the purples: one was "*faint, approaching to a scarlet*," and that was the least esteemed; another was "*a very dull red, approaching to a violet*;" and a third was a color compared to "*coagulated bullock's blood*." The most esteemed Tyrian purple seems to have been of the last color: we say the most esteemed, because it appears that even the Tyrian purple was not one particular color, but a class of animal dyes as distinguished from vegetable, varying in shades of purple from the most faint to the most intense. It is to be understood, however, that the Tyrian purples were more esteemed than any other colors, although they differed in degree of value. Of the vegetable purples we know nothing; most of the information relates to the purple of the Phœnicians. Their dye was obtained from several varieties of shell-fish, comprehended under two species,—one (Buccinum) found in cliffs, and the other (Purpura or Pelagia) which was the proper purple fish taken at sea: the first was found on the coast of the Mediterranean and Atlantic, and locally differed in the tint and value of the dye which they furnished. The Atlantic shell afforded the darkest color; and those of the Phœnician coast itself, and in general on the southern coast of the Mediterranean, yielded scarlet colors.

The Greeks, who were never at a loss to invent an ingenious fable to cover their ignorance of origin and causes, attributed the discovery of purple to the dog of Hercules, which it

is said, "in a range along the shore, instigated by hunger, met with a shell-fish, and greedily crushed it between its teeth: instantly an indelible purple stained its muzzle, and which color was afterwards applied to the dyeing of wool with great success."

"Colored dresses," says Pliny,* "were known in the time of Homer (who is supposed to have lived B. C. 900), from which the robes of triumph were borrowed."

The purple mentioned in *Exodus* was probably that dyed by the Tyrians. Ezekiel, in his prophecy against Tyre, says: "Fine linen with broidered work from Egypt, was that which thou spreadest forth to be thy sail; blue and purple from the isles of Elishah was that which covered thee." It is generally supposed, that by Elishah, Elis, on the western coast of the Greek Peloponnesus, was referred to: hence it would appear that the Tyrians, in the time of Ezekiel, obtained their supply of shell-fish for dyeing purple from the coast of Greece.

Ovid, in his description of the contest in weaving between Minerva and Arachne, dwells not only on the beauty of the figures which the rivals wove, but also mentions the delicacy of shading by which the various colors were made to harmonize together:—

> Then both their mantles button'd to their breast,
> Their skilful fingers ply with willing haste,
> And work with pleasure, while they cheer the eye
> With *glowing purple* of the *Tyrian dye:*
> Or justly intermixing shades with light,
> Their colorings insensibly unite
> As when a shower, transpierced with sunny rays,
> Its mighty arch along the heaven displays;
> From whence a thousand different colors rise
> Whose fine transition cheats the clearest eyes;
> So like the intermingled shading seems
> And only differs in the last extremes.
> Then threads of gold both artfully dispose,
> And, as each part in just proportion rose,
> Some antic fable in their work disclose.—
>
> *Metam.* vi.

Swinburne, in his Travels in the Two Sicilies, gives us the

* Pliny, viii. 48.

following interesting account of the purple dye:—"Near the Alcanterine convent is a small hillock, wholly formed of the shells of fish, employed by the ancients in the composition of the purple dye, and not far from it are the remains of some reservoirs and conduits appertaining to the works. My readers may not be sorry to meet with a description of the testaceous fishes that furnished the precious ingredient, and of the method used in extracting and preparing it, taken from the accounts extant in the classic authors, and the dissertations of modern naturalists.

"Purple was produced from two sorts of shell-fish, the *Murex* and the *Purpura*, both belonging to the testaceous or third genus of Linnæus' sixth class. From the former a *dark blue* color was obtained; the latter gave a *bright tint*, approaching to scarlet. The body of the animal that inhabits these shells consists of three parts; the lowest containing the bowels, remains fixed in the twisted screws at the bottom, for the purpose of performing the digestive functions; it is fleshy and tinged with the color of the food; the middle division is of a callous substance and full of liquor, which, if let out of its bag, will stain the whole animal and its habitation; the third and upper part is made of the member necessary for procuring food and propagating the race. The Murex generally remains fastened to rocks and stones; the Purpura being a fish of prey, is by nature a rover, and one of the most voracious animals of the deep: the proper season for dragging for this shell-fish was in autumn and winter. To come at the liquor, the shell was broken with one smart blow, and the pouch extracted with the greatest nicety by means of a hook. If the shells were of small size, they were thrown by heaps into the mill and pounded.

"The veins were laid in a cistern, salt was strewed over them, to cause them to purge and keep sweet, in the proportion of twenty ounces of salt to one hundred pounds of fish. They were thus macerated for three days, after which the mucilage was drawn off in a leaden cauldron, in order that the colors (by being heated therein) might acquire additional lustre and vivacity, as all marine colors do, by mixture with that metal. To keep the vessel from melting, eighteen pounds of water were added to one hundred and fifty pounds of purple, and the heat given horizontally to the bottom, by means of a flue brought from a furnace. By this

process, fleshy particles were carried off, and the liquor left pure after about ten days' settling.

"The dye was tried by dipping locks of wool in it, till they had imbibed a dark blue color. As the color of the murex would not stand alone, the dyer always mixed a proportion of purpura juice with it. They steeped the wool for five hours, then shook, dried, and carded it; dipped it in again and again, till it was saturated with the dye. The preparation requisite for staining 50lbs. of wool, with the finest deep amethyst color, was twenty pounds murex to one hundred and ten pounds of purpura. To produce the Tyrian purple, which resembles the color of coagulated blood, it was necessary, first to steep the wool in pure unboiled purpura juice, and then let it lie and simmer with that of the murex. By different mixtures of these two dyes, varieties were obtained according to the changes of fashion, which ran into violet till the reign of Augustus, when it inclined to the *Tarentine scarlet;* and this soon afterwards made way for the *Dyabasa Tyrica*, the most extravagant dye of all the tints. We read of fleeces being dyed upon the backs of sheep, but remain in the dark as to the method and advantage of that process."

Notwithstanding the enormous price of purple in the time of Augustus, the Roman emperor, such was the wealth accumulated in that capital, that many of the leading citizens decorated themselves in purple attire, till the emperors arrogated to themselves the privilege of wearing it, and prohibited its use to every other person. This prohibition operated so much to discourage the art, as eventually to occasion its extinction, first in the Western, and then in the Eastern empire, in the latter of which, however, it existed in several imperial manufactories till the eleventh century.

There has been some difference of opinion respecting the *scarlet* mentioned in the Scriptures: some think it is merely one of the Phœnician purples produced from the shell-fish: others hesitate to say whether the crimson or scarlet is intended by the word "scarlet," and by its equivalent in other languages. Besides the dye produced by the murex, a crimson or scarlet was found in ancient times obtained from an

insect akin to the American cochineal, but producing a most inferior color. The insect was called Kermes* (whence the name carmine crimson) by the Arabs, and Coccus by the Greeks and Romans.† The female insect is about the size and shape of a pea, of deep violet color, powdered with white, found chiefly on the leaves of a species of evergreen oak shrub (ilex aculcata) which grows in different parts of Western Asia and the whole of Europe. Now, that the color afforded by this insect was the scarlet of Moses, seems tolerably clear. The word rendered "scarlet" in the books of Moses, was a worm; and according to the analogy in the use of the word, kermes would literally be rendered "*wormdye.*" The word is variously interpreted to mean either "double dyed," or "the best scarlet," and seems to have been, according to another derivation, "bright deep red dye:" the terms together seem sufficiently to point out a species of coccus, doubtlesss the coccus ilius. It is so understood by the Septuagint and Vulgate. Professor Tychsen tells us that tola was the ancient Phœnician name for the dye used by the Hebrews, and even by the Syrian translation in Isaiah, c. i. v. 18, "*Come now, and let us reason together, saith the Lord: though your sins are as scarlet, they shall be white as snow; though they be red like crimson, they shall be as wool.*" After the captivity, the Jews more commonly used the Armenian word Zeheri. The same learned orientalist thinks that the dye was discovered by the Phœnicians, and if so, and if they were the great managers of this, as well as of the purple dyes, it would be useful to ascertain the difference in application, appearance, and quality, between this and the purple scarlet. Was their former scarlet this, or that pro-

* See chapter III., of this Part, article *Kermes*.

† In Germany, during the ninth, twelfth, thirteenth, and fourteenth centuries, the rural serfs were bound to deliver annually to the convents, a certain quantity of kermes, the *coccus polonicus*, among the other products of husbandry. It was collected from the trees upon St. John's day, between eleven o'clock and noon, with religious ceremonies, and was therefore called *Johannisblut* (Saint John's blood), as also German cochineal. At the above period, a great deal of the German kermes was consumed in Venice, for dyeing the scarlet to which that city gives its name.

duced by the shell-fish? We incline to think it was the coccus, and that the scarlet of the first dyes was only used in modifying the purple; and we arrive at this conclusion because, while a scarlet is mentioned as the basis of the ancient purple, the scarlet is always noticed as something distinct from the the purple. We imagine the distinction between the two has been, that the purple scarlet was crimson, while the kermes scarlet was the red scarlet, or perhaps more properly vermilion (the worm scarlet). Professor Tychsen, supposing the identity of the scripture scarlet with the kermes established, properly concludes that the kermes-dye was known before the time of Moses; that the dye was known to the Egyptians at the time of Moses, for the Israelites must have carried it along with them from Egypt; that the Arabs received the name "kermes" with the dye from Armenia or Persia, where it was indigenous, and had been long known, and that that name banished the old name in the East, as the name scarlet has in the West. The kermes were, perhaps, not known in Arabia, at least they were not indigenous, as the Arabs appear to have had no name for them.

The art of dyeing the fine red, called Turkey or Adrianople red, on *thread* or *yarn*, has, as is well known, been practised in the Levant from a very remote period, and from whence it was introduced into Europe.

The ancient Egyptians and Phœnicians were not only acquainted with *topical* dyeing, or the art of producing colored patterns on cloth, but also, of extracting iron, copper, gold, silver, lead, and tin from the ores containing these metals. They extracted *soda* from the soil in which that alkali naturally exists, and understood the means of purifying it: they procured *potash* from the ashes of plants, and made *soap* by combining the alkalis with oils and fats. They were acquainted with the mode of converting an alkaline carbonate into a caustic alkali by the action of quick-lime, and even took advantage of this property of lime to give to soda (carbonate of soda) a degree of causticity which deceived the purchasers of this article as to its real value. The arts of making earthenware, glass (both colorless and colored), porce-

lain, and various pigments, and certain processes in dyeing, were brought to a state of perfection not exceeded, nay, in some instances, not equalled, by artists of the present day.

From the following account by Pliny of the nature of the process of topical dyeing practised by the ancient Egyptians, it would appear that this people had attained such proficiency in the art; as could only have been originally acquired by extensive practice and close observation.

An extraordinary method of *staining* cloths is practised in Egypt. They there take white cloths and apply to them, not colors, but certain drugs which have the power of absorbing or drinking in color; and in the cloths so operated on there is not the smallest appearance of any dye or tincture. These cloths are then put in a cauldron of hot coloring matter, and after having remained a short time are withdrawn, *all stained and painted in various colors*. This is indeed a wonderful process, seeing that there is, in the said cauldron, only one kind of coloring material, yet from it the cloth acquires this and that color, and the boiling liquor itself also changes, according to the quality and nature of the dye-absorbing drugs which were at first laid on the white cloth. And these stains or colors, moreover, *are so firmly fixed as to be incapable of being removed by washing*. If the scalding liquor were composed of various tinctures and colors, it would doubtless have confounded them all in one on the cloth; but here one liquor gives a variety of colors, according to the drugs previously applied. The colors of the cloths thus prepared are always more firm and durable than if the cloths were not dipped into the boiling cauldron.*

From this it is evident that the cloth was prepared before steeping; the *momentary* effect he mentions could only be produced by the powerful agency of mordants, and they not only used them to make the cloth take the color equally, but also to change the hues.

Herodotus (book 1. c. 203,) gives us the following account of a nation on the borders of the Caspian, who painted figures of animals on their garments with a vegetable dye:—

"They have trees whose leaves possess a most singular property: they beat them to powder, and then steep them in water: this forms a dye, with which they paint on their garments figures of animals. The impression is so very strong that it cannot be washed out; it appears to be interwoven in the cloth, and wears as long as the garment."

* Pliny, Hist. Nat., lib. xxxv. cap. 11.

He does not, however, state the material of which the garments were made. Strabo, and the author of the Periplus, also celebrate the beautiful flowered cottons of India, and the brilliant and various dyes of that country. And from the very early civilization of the Indians, and their stationary condition for several thousand years, it may be inferred that calico-printing existed amongst them many ages before the time of Alexander.

"In Cambaia there is," says Marco Polo, "abundance of cotton cloth, as well as of cotton in the wool; and a great quantity of *indigo* is manufactured."*

The Chinese practised block printing before any species of printing was known in Europe. Calico printing is practised in Asia Minor, Turkey, and indeed in all the countries of the East, by such means and processes as prove clearly the Eastern origin of the art. The processes of calico printing in India are described in certain letters written by Father Cœurdoux, a missionary at Pondicherry, published in Vol. 26, of Recueil des Lettres Edifiantes et Curieuses;" from which Dr. Bancroft has drawn up his account in his "Philosophy of Permanent Colors."†

According to Clavigero, the Mexicans were acquainted with the art of dyeing at a very remote period. "The colors," he says, "of the cotton were extremely fine."‡ This, however, is not to be wondered at, since they had both indigo and cochineal among their native dyes.

Calico-Printing does not appear to have been practiced in Europe until the close of the seventeenth century, and as the *History* of the art since that period is well known, we need not offer any remarks upon the subject. For the space already allotted to its *Ancient History*, we crave the indulgence of practical dyers and calico printers.

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* "Qui," says Barbosa, "si lavorano assai tele e panni di gotton bianchi, sottili e grossi e di varie sorte tessuti et difinti." Here we see the antiquity of the printed calico manufacture.

† Vol. i. p. 350.

‡ Clavigero's History of Mexico, book vii.

CHAPTER II.

FIRST PRINCIPLES OF DYEING.

Object of Dyeing Operations—Theories of Light and Color—Analogy between Color and Sound—Chemical Knowledge indispensable to the Dyer—Elements of Vegetable Substances—Action of Acids upon them—Influence of Light upon Vegetables—Coloring Matter of Flowers—Application to Dyeing.

THE great object of all dyeing operations is, the impregnation of wool, silk, cotton, linen, hair, and skins, with coloring substances derived from animals, vegetables and minerals, in such a manner as to render them incapable of being removed by washing with water. The modes of effecting this object vary as greatly as the coloring matters differ from each other in their chemical habitudes. Though the chemical re-actions which are exhibited in the various dyeing and printing processes are, for the most part, sufficiently intelligible, yet they are sometimes of a highly complex character; and the theoretical principles of a few valuable processes, discovered accidentally, are even yet but imperfectly understood.

We shall in this chapter consider the first principles of the art, referring for the particular dyes, and peculiar treatment of the stuffs to be dyed, to the different tinctorial substances in their proper places, such as cochineal, indigo, madder, &c.; our object being to point out the laws upon which the theory of colors depends, and the necessity of *practical* men studying these laws.

Color is the result of the mutual operation of the *active* and *passive* principles of light and darkness; for the action of light being partially interrupted in the production of this phenomenon, every color is consequently allied to both—to the latter as well as to the former. Color is therefore an intermediate phenomenon, the perception of which, like light

itself, is conveyed to the mind through the most perfect of our senses, whether in regard to the accuracy and variety of the information it affords or the pleasure we derive from its exercise. The impression made upon this sense, which conveys to the understanding the perception of light and color, we receive as we do sound, by means of some inherent quality in the atmosphere; a few observations upon which, and upon the manner in which it is, or may be, supposed to be acted upon, *in the production of colors*, shall be here attempted.

Natural philosophers do not appear to have yet arrived at a precise understanding of the nature and properties of light, the consequence of which has been the promulgation of many theories, compounded almost wholly of mere conjecture. But the first theory generally adopted as correct, was the hypothesis that light consists of excessively minute material particles, or molecules, thrown off from the luminous body, whence they emanate with great volocity; diverging in all directions, and always in straight lines. This theory was conceived by Newton, and is called the Newtonian theory. The particles thus thrown off are supposed to be possessed of inertia, and endowed with attractive and repulsive forces, and are emitted from all luminous bodies with nearly the same velocity, about 200,000 miles per second;—that they differ from each other in the intensity of the attractive and repulsive forces which reside in them; and that, impinging on the retina, they stimulate it, and excite vision; producing color, at the same time, by their different degrees of inertia. It is also supposed that their action upon the molecules of material bodies, and *vice versa*, is that of attraction and repulsion.

Another doctrine maintains, that light is caused by the independent motion of an imaginary fluid called ether, diffused throughout all space, in which waves or undulations are produced by the action of luminous bodies, and propagated in the same manner as sound is, by ærial pulsations. This hypothesis was advanced by Huygens, and is called the Huygenian theory. The fluid or elastic medium just spoken of, is supposed to be so subtle as to offer no appreciable resistance to the motions of the planets; and is believed to penetrate all

bodies, but to possess a different degree of intensity and elasticity in their interior, to that which belongs to it in a disengaged state.

But neither of these theories seems to agree with many ascertained facts in natural philosophy; nor does either of them account in a satisfactory manner for the various phenomena connected with the transmission, reflection, refraction, and velocity of light.

If light be composed of material particles, it is not easy to conceive how they should become weaker as they recede from the luminous body whence they emanated, while their velocity, as is admitted, continues the same; nor is it easy to conceive how they should be reflected in such variety from opaque bodies, and change their character when transmitted through those that are transparent. Besides, material particles emanating in straight lines from a convex surface, must separate and become more diffused as they recede from it; consequently, light, under such circumstances, instead of becoming gradually weaker, would become necessarily mottled. These, and various other objections, especially that regarding the transmission of light through apparently solid bodies, have been often raised against this theory, but never satisfactorily answered.

Again, to conceive that there is a separate and distinct fluid co-existing with the common atmospheric air, for the purpose of conveying light by undulation, in the same manner as the former is acted upon by vibratory bodies when put in motion, is to conceive a complexity of means greatly at variance with the general simplicity of those by which, so far as they have been investigated, the other wonderful operations of nature are performed. Neither does such a supposition appear consistent with many facts regarding the nature and properties of sound, nor even with those of light, as ascertained by the experimental enquiries of those great men themselves whose names have been mentioned, or of the other eminent philosophers who have followed out their investigations. One of the most celebrated of the latter* observes, "the fact is, that neither the

* Sir J. F. W. Herschel.

corpuscular," (the Newtonian theory,) "nor the undulatory," (the Huygenian theory,) "nor any other system which has yet been devised, will furnish that complete and satisfactory explanation of all the phenomena of light which is desirable."

The atmosphere has been ascertained to be an elastic fluid, impenetrable, inert, movable, and possessed of a certain gravity, reducible in proportion to the degree of attenuation to which it may be subjected. It cannot be annihilated, and in its attenuated state it retains the same proportions in its gaseous elements. The fact has also been ascertained that the atmosphere, when pure, is composed of two gases, with the admixture of a small proportion of aqueous vapor and carbonic acid.* We know that it is at the same time the common receptacle of all the vapors and exhalations that arise from the earth, and which diffuse themselves gradually through it, and as gradually unite again by the principle of affinity or gravitation. To each of the elements just mentioned as constituting by their combination atmospheric air, a specific use in the economy of the animal and vegetable creation may be assigned, except to the aqueous vapor; the simple fact of whose presence, however, is, alone, sufficient assurance of its having a purpose to serve, *since in the productions of nature there is nothing superfluous.* Now, as the atmosphere is admitted to be a body, may we not suppose that it is constituted like other elastic bodies, though it cannot, like those that are solid, be brought within the sphere of microscopical investigation, and that this aqueous vapor is distributed throughout the atomic interstices in the form of an infinitely minute and symmetrically reticulated fibrous tissue, susceptible of tension and attenuation, like that known to exist in animal and vegetable substances?

By such a supposed distribution of the aqueous vapor, an

* The proportions of these elements are as follows:—

	By Weight.	By Measure
Nitrogen Gas,	77.50	75.55
Oxygen Gas,	21.00	23.32
Aqueous Vapor,	1.41	1.03
Carbonic Acid,	0.08	0.10

independent vehicle of sound is at once supplied, and the gaseous elements of the atmosphere left to perform their wonderful and important duties in the economy of the creation, undisturbed. By such a supposition, too, regarding the constitution of the atmosphere, and of liquid and aeriform bodies generally, their various capabilities of condensation and attenuation would perhaps be more easily accounted for; as also the phenomenon in accoustics produced by the attenuation of atmospheric air under the receiver of an air-pump, when it so far loses its vibratory power as to become, in consequence, incapable of conveying sound. The supposition here hazarded, will also satisfactorily account for the greater facility with which sound is transmited in the lower regions of the atmosphere, where the relative proportion of the aqueous vapor to that of the gaseous elements is greater than in its higher regions.

The manner in which smoke and other visible vapors are observed to diffuse themselves through the atmosphere, the phenomenon of snow assuming beautiful hexagonal figures, as well as the extremely elegant appearance and combinations which hoar-frost presents when minutely examined, favor the supposition now advanced. Because, unless there were in the body of the atmosphere symmetrical reticulation, we should not find in snow-flakes the uniform figures which they present, and which, it is presumed, they could not otherwise acquire than by passing through such a medium.

The gases which enter into the composition of atmospheric air, as well as all other gases, are, according to a well established theory, composed of atoms or molecules. Now, adopting this theory, may not the sun or any other luminous body possess a power of acting upon the atomic particles of one or both of these gases electrically or otherwise, in such a manner as to put them into harmonic motion amongst themselves, each upon its own axis, and rendering them luminous by friction, thus producing white light? May not the partial interruption or change in the mode of this atomic motion produce *shades* and *colors*, and its total interruption *blackness*? As every material body is also understood to be composed of atoms or

molecules, may it not likewise be reasonably supposed that the modes of arrangement, or the configuration of these atoms, render them capable of receiving this motion of light, in ways infinitely various, producing *every variety of color?* May not *dyeing* be simply the production of *a change in the arrangement of the atoms* of which the substance dyed is composed, thus affecting the atomic action of light upon its surface? May not the mode of arrangement in the atoms of crystals and other transparent media be thus affected, and made to communicate a like motion to those of the atmosphere beyond them, producing *colored light*, as those atoms on the surface of opaque bodies reflect it?

That light does act in some such manner, seems certain, from a communication made on 20th December 1843, to the Microscopical Society, by Mr. Ross, relative to the daguerreotype process first noticed by Mr. Solly—"If an ordinary daguerreotype portrait be examined with a power of about 200 linear, the surface in the parts upon which the light has acted, is found to be covered with a series of minute dots or globules arranged in a hexagonal form."*

It seems an ascertained fact, though by the theories hitherto advanced difficult to be accounted for, that the velocity of the transmission of light is in no way dependent on the strength of the light transmitted, and that the reflected light of the moon travels with equal velocity as the direct light of the sun. But by this supposed atomic motion, the difficulty seems removed; for, whether rapid or slow in itself, it may be communicated with equal velocity, in the same manner that the rotatory motion of a notched wheel, *at the end of a series of any conceivable length*, would transmit to the wheel at the other end a similar motion almost instantaneously.

All this may be easily supposed to take place independently of any vibration, undulation, or other motion in the fibrous tissue, or even in the gases themselves, for we know that when the atmosphere is in a progressive motion, its vibrations follow the direction of its progress. For instance, when the

* *Athenæum*, No. 844.

wind blows strongly from east to west, or *vice versa*, a sound is not transmitted so rapidly or distinctly from south to north as when the wind blows in that direction; while the sun's rays, or those of any other light, are equally direct, and proceed with the same velocity, whatever may be the motion of the body of the atmosphere at the time. It may, therefore, be supposed, that the motion producing light and color is imparted to the atoms while following the course of the general body of the atmosphere as they come in contact with those under the direct influence of the luminous body, and that this motion is communicated with the rapidity of electricity, which supposition is not inconsistent with other phenomena in nature.

The hypothesis that *variously colored rays* emanate from the sun, each possessing a different degree of intensity, has given rise to the supposition, that there may possibly be *a multitude of rays of each color* moving with various velocities, and only affecting the sense when they have the velocity appropriate to that color in the eye.* But the hypothesis of atomic motion here suggested, is independent of any such complicated process, for although the motion it supposes to be communicated by luminous bodies to the gaseous atoms may be various, the progress of the communication may be perfectly uniform. This hypothesis may also satisfactorily account for the reduced velocity of light when it enters a denser medium.

We know that motion produces friction, and that friction produces electricity. If light, therefore, be produced by motion amongst the gaseous atoms that enter into the composition of all matter, the mode of its production must resemble that of electricity, which it must consequently resemble also in its nature.

It is known that electricity is generated in the atmosphere, in greatest quantities, at that particular season of the year when the sun exercises the greatest influence on it—may not this atomic friction be the cause? Friction produces heat,

* Encyclopædia Britannica.—Article, *Chromatics.*

heat ignition, and ignition produces light. If the rays of the sun be concentrated, such concentration produces the effect of friction in causing ignition, and when ignition is communicated from one body to another, rapid motion of the air which surrounds the body accompanies its decomposition.

Goethe, in his admirable "Theory of Colors," says, "In examining every appearance of nature, but especially in examining an important and striking one, we should not remain in one spot, we should not confine ourselves to the insulated fact, nor dwell on it exclusively, but look round through all nature to see where something similar, something that has affinity to it, appears; for it is only by combining analogies that we gradually arrive at a whole which speaks for itself, and requires no further explanation." Such an analogy is found between sound and light, and is in no way at variance with the idea of light being the result of an independent motion of the gaseous molecules in the atmosphere. It is an established fact, that sound is the result of vibratory motions or undulations produced in the atmosphere, similar to the undulations of water into which a stone or other substance has been thrown, with this difference, that in the one case they are apparently superficial, in the other known to be spherical, diverging equally on all sides, perpendicularly and laterally. The effect of this motion in the atmosphere is far from being uniform: sound is undoubtedly the result, but this result is produced in various degrees of modification as to pitch and tone, and these degrees have been ascertained to be communicated through the atmosphere with equal velocity. It has also been ascertained, that a musical note produced by this pulsatory motion in the atmosphere, is invariably accompanied by other sounds called harmonies, in a manner quite perceptible to a fine ear; and that this accompaniment bears the same mathematical relation to the original note that the three primary elements of color bear to each of their constituents.

Sir David Brewster has shown, that no refracting power is capable of perfectly separating the three colors now universally acknowledged to be the primary elements of chromatics;

for however bright they may be made to appear in the solar spectrum, they still have individually an admixture of one of the other two. We are thus made aware that not only do the elements of sound agree in number with those of color, but also in their affinities, and they also have, in their effects upon the senses to which they are respectively addressed, the most perfect analogy.

The more we investigate the operations of nature, the more we become convinced of the simplicity of the means by which the phenomena that are daily attracting our attention are performed. If, therefore, we can account for the phenomena of *light* and *color* as satisfactorily by the means known to exist, as by supposing the necessity of material particles, or an ethereal fluid, to assist these; the subject is simplified, and so far agrees with the facts which philosophy has brought within the sphere of our knowledge.

From these observations it is obvious that the dyer in order to understand the nature of his business, and to give the best possible effects to the various colors he produces, *should be acquainted with the laws of light in relation to colors.* But, were he to take this alone as his guide, he would find that in attempting to realize the results of the preceding theories by mixing his colors accordingly, in some instances he would not succeed; as for instance, were he attempting to produce a white by immersing the goods in a mixture of red, yellow, and blue colors, he would get a brown—but this does not invalidate the law above described, and, in fact, the practice of producing white by the combining the three colors is had recourse to every day by the *practical* bleacher and dyer. All goods coming from the bleaching process, no matter what the nature of the process has been, have always a brownish yellow tinge: to cotton goods a little indigo or cobalt blue is added, and the result is, a much purer white: to silk, which has more of the yellow tinge than cotton, a little Prussian blue and cochineal pink; or what is more common, a little archil, which gives a violet color, is added; the quantity varying according to the depth of yellow—the result is a

beautiful white.* The necessity of having a pure white upon goods before being dyed, and the best means of obtaining this, will be given under the head of Bleaching.†

The scientific theories of *light* and *color* having been illustrated, we may appropriately offer a few observations on the analogy which exists between color and sound.

It is well known that a remarkable conformity exists between the science of color and that of sound, in their fundamental principles, as well as in their effects. We shall probably best lead the reader to a proper comprehension of the former by tracing this analogy, the more especially as the science of music is much more generally understood. This analogy will help to show, that the laws which govern color are as irrefragable, and, at the same time, *as practically necessary to the colorist in art, manufacture, or decoration*, as those which govern sound are to the musician.

It is well known to all who have studied music, that there are three fundamental notes, viz., the first, third, and fifth of the scale, represented in the natural key of C major, by the letters C, E, and G. These notes, when sounded together, produce the common chord, and are the foundation of all harmony in musical composition. So it is in chromatics,—there are likewise only three fundamental colors,—blue, red, and yellow, forming the triad from which arises all harmony in painting.

By the combination of any two of these primary colors, a secondary color of a distinct kind is produced; and as only

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* In Syme's Nomenclature of Colors, there are no fewer than eight different tints of white enumerated; and although the terms reddish white, &c., are rather anomalous, yet there seems no other way of denominating the lightest tints of colors. For instance, when the lightest tint of any color is placed beside the most intense, it will appear to the eye a pure white; but when placed beside the purest white, the color will appear with which it is tinged. Still it should be understood, that if it be a single shade beyond the first remove or gradation from pure white, its name must be altered to a light tint of the color with which it is tinged.

The only white which is generally understood or used besides the purest tint, is French white, which is, properly speaking, the lightest tint of purple, and is of all colors the most delicate and aerial.

† See Bleaching, Part ii.; see also chapter II. Part iii., article, *Purity of Water*.

one absolutely distinct denomination of color can arise from a combination of the three primaries, the full number of really distinct colors is seven, corresponding to the seven notes in the complete scale of the musician. Each of these colors is capable of forming an *archeus* or key for an arrangement, to which all the other colors introduced must refer subordinately. This reference and subordination to one particular color, as is the case in regard to the key-note in musical composition, gives a character to the whole.

This characteristic of an arrangement of color is generally called its tone; but it appears to us that this term is more applicable to individual hues, as it is in music to voices and instruments alone. Yet, to avoid obscurity, we shall continue to use it in the sense in which it is generally applied to coloring.

From the three primary colors, as will be afterwards shown, arise an infinite variety of hues, tints, and shades; so that the dyer or colorist, like the musician, notwithstanding the limited number of the fundamental parts of his art, has ample scope for the production of originality and beauty in the various combinations and arrangements of which they are susceptible.

The three homogeneous colors, yellow, red, and blue, have been proved by Field, in the most satisfactory manner, to be in numerical proportional power as follows—yellow three, red five, and blue eight.

When these three colors are reflected from any opaque body in those proportions, white is produced. They are then in an active state, but each is neutralized by the relative effect that the others have upon it. When they are absorbed in the same proportions, they are in a passive state, and black is the result. When transmitted through any transparent body, the effect is the same; but in the first case they are material or inherent, and in the second impalpable or transient. Color, therefore, *depends entirely on the reflective or refractive power of bodies*, as the transmission or reflection of sound does upon their vibratory powers.

From the combination of the primary colors the secondary

arise, and are orange, which is composed of yellow and red, in the proportion of three and five; purple, which is composed of red and blue, in the proportion of five and eight; and green, composed of yellow and blue, in the proportion of three and eight. These are called the accidental or contrasting colors to the primaries, with which they produce harmony in opposition, in the same manner in which it is effected in music by accompaniment; the orange with the blue, the purple with the yellow, and the green with the red. These colors, therefore, neutralize each other at sixteen.

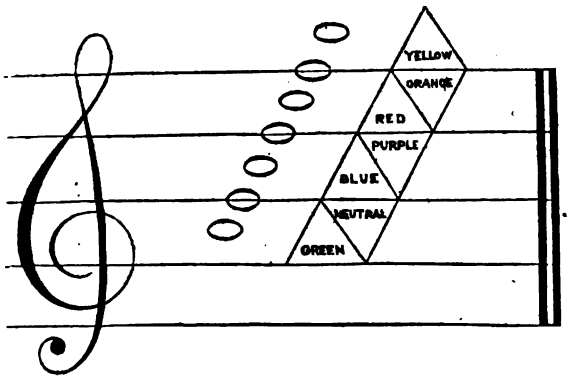
This neutralizing or compensating power is the foundation of all agreement and harmony amongst colors, and upon it depends also the brilliancy and force of every composition.

From the combination of these secondaries arise the tertiaries, which are also three in number, as follow: olive, from the mixture of the purple and green, citron, from the mixture of the green and orange, and russet, from the mixture of the orange and purple. These three colors, however, like the compounds produced by their admixture, may be reckoned under the general denomination of neutral hues, as they are all formed by a mixture of the same ingredients; the three primaries, which always, less or more, neutralize each other in triunity. The most neutral of them all being grey, and the mean between black and white, as any of the secondaries are between two of the primaries, it may appropriately be termed the seventh color. These tertiaries, however, stand in the same relation to the secondaries that the secondaries do to the primaries—olive to orange, citron to purple, and russet to green; and their proportion will be found to be in the same accordance, and neutralizing each other integrally as 32.

Out of the tertiaries arise a series of other colors, such as brown, marone, slate, &c., in an incalculable gradation, until they arrive at a perfect neutrality in black. To all these the same rules of contrast are equally applicable.

Besides this relation of contrast in opposition, colors have a relation in series, which is their melody. This melody, or harmony of succession, is found in all the natural phenomena of color. Each color on the prismatic spectrum, and in the

rainbow, is melodized by the two compounds which it forms with the other two primaries. For instance, the yellow is melodized by the orange on the one side, and the green on the other; the blue by the green and purple, and the red by the purple and orange. Field, in his excellent Essay on the Analogy and Harmony of Colors, has shown these coincidences by a diagram, in which he has accommodated the chromatic scale *of the colorist* to the diatonic series *of the musician*, showing that the concords and discords are also singularly coincident. It is, however, too complex for a work of this kind; we shall, therefore, content ourselves by giving one of the three clefs only, as in the following example:—



We cannot conclude this part of the subject, without noticing a striking coincidence between color and sound, which seems to render the analogy perfect. We have already mentioned the phenomenon discovered by Buffon, of the accidental color which appears with any given color, and that such accidental or compensating color makes up the harmonious triad or concord. This is precisely the case when any given note is sounded on an instrument. It is always accompanied, or immediately succeeded, by those which form a chord, and are termed in music the harmonics. This phenomenon in acoustics, we believe, is most perceptible in the sound of a bell in succession, and in accompaniment on the string of the violoncello.

We shall now turn our attention to the consideration of the chemical changes which are supposed to take place in nature, giving rise to the various colors presented to us in the vegetable kingdom, which will greatly aid us in describing the artificial means of imitating nature in these colors, although as yet there is comparatively little known concerning the nature of these changes. For a long time, chemists considered iron to be the coloring principle of all animals and vegetables, being almost universally diffused, and capable of assuming a variety of colors, either as oxides or solutions; but it was afterwards demonstrated that the iron present in any vegetable, even in those where it existed most abundantly, was altogether inadequate to produce the splendid colors which vegetables assume. Several other hypotheses were proposed to account for the colors of vegetables; but these hypotheses, not being founded upon inquiry and proof, died at their birth. It is only within these few years that the true method of ascertaining the nature and cause of vegetable colors has been adopted; that is, by the ultimate analysis of vegetable substances in all the stages of existence; and since then, a number of important facts have been made known respecting this interesting subject, and new ones are daily being added; and we hope that these discoveries may be speedily made available by the *practical* man.

The principal elements of vegetable substances are, oxygen, hydrogen, carbon, and nitrogen: the last exists in such a minute quantity, that in many cases it is scarcely appreciable; but according to the opinion of Liebig, who stands at the head of this department of chemistry, it is never absent. There is also a variety of earthy substances in vegetables, such as lime, iron, magnesia, soda, potash, &c.; but, all these never exist in one vegetable—some of them seem indispensable for the existence of a plant; but they differ according to the nature of the plant, and the soil on which it grows. The three elements, oxygen, hydrogen, and carbon, enter very abundantly into the composition of vegetables, forming from 95 to 99 per cent.; but it must not be supposed from this, that all vegetables are alike in their chemical properties—they may

be as varied as those substances which constitute the mineral kingdom. This depends upon a well-known law in chemistry, termed the law of definite proportions; that is, every compound substance has a particular number of elements, and a definite number of each element. The following table, showing the composition of a few compounds which constitute a great mass of all vegetables, will serve to illustrate this.

	Carbon.	Oxygen.	Hydrogen.
Woody fibre, . .	15	10	10
Gum, . . .	12	11	11
Starch, . . .	12	10	10
Sugar, . . .	12	11	11

It will be observed from the above table how little is necessary to produce an entire different compound. It will also be observed, that gum and sugar are the same: this appears an exception to the law above described. Those bodies which have their elements in the same proportion, are termed *isomeric* (see Tartaric Acid), signifying *equal parts*. The discovery of bodies having the same number of elements, and differing in their chemical properties, excited much interest among *chemists*, and has led to much careful study and investigation, and the result has been rather unfavorable to the doctrine of isomerism: they are substances which the French would designate the *same* with a *difference*—the difference is supposed to be in the numerical arrangement of the elements. As for example, hydrogen and carbon will combine in the proportion of two and two, four and four, and eight and eight, forming three substances, differing considerably in chemical properties, although the elements are combined in the same proportion; but, interesting as this subject is, we cannot in the mean time enter into any lengthened details—it shows us, however, the extensive means employed by nature for giving variety of substances. Another thing to be observed from the above table is, that the oxygen and hydrogen in each of these compounds are in the same proportion, or in that relative proportion in which they unite to form water. Now, it may be stated as a general rule, that when

oxygen and hydrogen are united to carbon, in the proportion in which they form water, the resulting compounds are of a saccharine or mucilaginous character.

When vegetable compounds have hydrogen united to carbon without oxygen, or when there is less of that element than would be required to convert the hydrogen into water, the resulting compounds are generally oily, resinous, or alcoholic. A table of the composition of a few of these substances will illustrate this :—

	Carbon.	Hydrogen.	Oxygen.
Oil of turpentine,	10	8	
Oil of potatoes,	5	6	1
Oil of cloves,	23	14	5
Resin of gamboge,	20	14	5
Caoutchouc,	4	4	
Bees' wax,	37	39	2
Pyroxilic spirit,	2	4	2
Alcohol,	2	3	1

When the proportion of oxygen united to carbon is in greater quantity than the hydrogen, or when none of this element is present, the resulting compounds have generally an acid character: green fruits are in this state, which gives them the sour taste, and makes them deleterious to health, either by giving too much acid to the stomach, or the acid being of a direct poisonous nature; but as the fruit ripens, it takes in or assimilates more hydrogen, and the acid, or at least part of the acid, is converted into a saccharine compound. The following table will show the composition of a few of the most common acids found in vegetables :—

	Carbon.	Oxygen.	Hydrogen.
Acetic acid (vinegar),	4	3	3
Tartaric acid,	4	5	2
Citric acid (lemon juice),	4	4	2
Gallic acid,	7	5	3
Tannic acid,	18	12	8

There are also a number of vegetable alkalies which are found united to acids in plants, which, however, need not be specially noticed here, further than that they almost all contain nitrogen as an ingredient. There are other substances in

which nitrogen enters into their composition, and which are useful in the production of colors by art, but which will be noticed under their respective heads.

Having given an outline of the nature and composition of the principal vegetable compounds, we shall now inquire into the cause of their assuming certain colors, and the effects which acids have upon these colors.

At the commencement of this chapter, we mentioned that color is the result of the mutual operation of the *active* and *passive* principles of light; but it may also be stated, that this result depends upon the chemical constitution of the particular substance; hence, the inquiry into the cause of vegetable colors becomes a chemical one; and, from chemical laws these colors must have a definite constitution; and when any change of color takes place, there must also be a change of chemical constitution. In prosecuting this inquiry, or rather, *in collecting the inquiries of the most eminent chemists upon this subject*, we shall begin with the paramount color of the vegetable kingdom, namely, green.

Green is well known to be a compound color, produced by yellow and blue, and is always induced upon cloth by dyeing it first the one and then the other. It is not always the yellow that is dyed first, according to the description in chemical books; but sometimes the blue, according to the nature of the dyeing agent, which will be explained in its proper place. Speaking of vegetable green, Berthollet says, "the green of plants is undoubtedly produced by a homogeneous substance, in the same way as the greater number of hues which exist in nature. This color owes, then, its origin sometimes to simple rays, and sometimes to the union of different rays; and some other colors are in the same predicament. Were the green of plants due to two substances, one of which is yellow and the other blue, it would be extraordinary if we could not separate them, or at least change their proportions by some solvent." This idea of Berthollet, that the green of plants is a distinct substance, existing in the plant, has been since verified. It is obtained by bruising green leaves into a pulp with water, pressing out all the liquid, and boiling the dry pulp in

alcohol: when the alcohol is evaporated, there remains a deep green matter, which, by digesting in water, dissolves, and frees it from a little brown coloring matter, with which it was mixed. This substance has been named *chlorophyllite*. The formation of chlorophyllite seems to depend entirely upon the action of the solar rays. "It is known that the function of the leaves and other green parts of plants is to absorb carbonic acid, and, with the aid of light and moisture, to appropriate its carbon. These processes are continually in operation: they commence with the formation of the leaves, and do not cease with their perfect development." But when light is absent, or, during the night, the decomposition of carbonic acid does not proceed; nay, carbonic acid is emitted, and oxygen gas absorbed: *it is evident then that a plant kept always excluded from the light, must have a difference in its composition.* "No one can have failed to observe the difference between vegetables thriving in the full enjoyment of light, and those which grow in obscure situations, or which are entirely deprived of its agency: the former are of brilliant tints; the latter dingy and white.* Numerous familiar instances might be cited, especially among our esculent vegetables: the shoots of a potato produced in a dark cellar are white, straggling, and differently formed from those which the plant exhibits under its usual circumstances of growth. Celery is cultivated for the table by carefully excluding the influence of the light upon its stem: this is effected by heaping the soil upon it, so as entirely to screen it from the solar rays; but if suffered to grow in the

* According to Goethe, the eye owes its existence to light, which calls forth, as it were, a sense that is akin to itself; or, in other words, that a dormant light resides in the eye, which may be excited from within or without. Goethe observes, "In darkness, we can, by an effort of our imagination, call up the brightest images; in dreams, objects appear to us as in broad daylight; awake, the slightest external action of light is perceptible, and if the organ suffers an actual shock, light and colors spring forth."

He likewise clearly shows that color is a law of nature in relation with the sense of sight, as well as an elementary phenomenon, which, "like all others, exhibits itself by separation and contrast, by commixture and union, by augmentation and neutralization, and by communication and dissolution." Under these general terms, the nature of color is fully comprehended.

ordinary way, it soon alters its aspect, throws out abundant shoots and leaves, and, instead of remaining white and of little taste, acquires a deep green color, and a peculiarly bitter and nauseous flavor. The heart of the common cabbage is another illustration, and the rosy-colored aspect of the sides of fruit is referable to the same cause. Changes yet more remarkable have been discovered in plants vegetating entirely out of the access of light. In visiting a coal-pit, Professor Robinson found a plant with a large white foliage, the form and appearance of which were quite new to him; it was left at the mouth of the pit, when the subterranean leaves died away, and common tansy sprung from the roots."*

From these facts we see that the green color of vegetables is owing to a peculiar approximate element existing in the vegetable, not invariably, nor altogether essential to the plant, but depending upon circumstances; these circumstances being at the same time the best for the health and existence of the plant. This color differs from the other colors of vegetables in the time of its appearing. Flowers of plants do not appear till the plant has reached a certain state of maturity; but whenever a plant rises above the soil, it immediately begins to assume the green hue, and this hue is continued till the object of the leaves is completed. When a chemical change takes place, the green passes away, and another color, reddish-yellow, takes its place. These changes are effected in different degrees, and in different lengths of time, just according as the leaves have the property of absorbing oxygen gas. Those leaves which continue longest green absorb oxygen slowest. The leaves of the holly will only absorb a small fraction of oxygen, in the same time that the leaves of the poplar and beech will absorb eight or nine times their bulk. These last are remarkable for the rapidity and ease with which the color of their leaves changes. That leaves do absorb oxygen gas when they change color at autumn, and that it is owing to the absorption of this gas, may be

* See Appendix, articles *Color, its influence on Odors*, and *Experiments and Observations on Light.*

verified by placing some green leaves of the poplar, the beech, and the holly, under the receiver of an air-pump, and drying them thoroughly, keeping them excluded from light; when taken out, wet them with water, and place them immediately under a glass globe, full of oxygen gas, they will change color; and it will be found that each will change color just in proportion to the quantity of oxygen it absorbs. The consequence of this absorption is the formation of an acid. This acid changes the chlorophyllite, or green principle, from green to yellow, and then to a reddish hue. If we treat green leaves with an acid, the same changes of color take place, and if we macerate a red leaf in potash it becomes green.

The various and beautiful colors of flowers are produced by a somewhat different process from that of the green of the leaves, in so far as they do not appear until the plant has attained a certain state of maturity. "The leaves of the plant being fully developed, they take in more nourishment from the atmosphere than what is necessary for the existence of the plant. This extra nourishment takes a new direction; a peculiar transformation takes place; new compounds are formed, which furnish constituents of the blossoms, fruit, and seed."*

It is very probable that all the colors of flowers depend upon only a few approximate elements formed in the vegetable, in the manner already described, and that their various hues are the consequence of the presence of acids affecting more or less this coloring substance. This is the most probable hypothesis that has been formed, and with which we must rest satisfied till more accurate experiments verify its truth, or give us a better. The following summary of experiments will give some idea of the views held upon this subject:—"The expressed juice of most red flowers is blue; hence it is probable that the coloring matter in the flower is reddened by an acid, which makes it escape when the juice is exposed to the air. The violet is well known to be colored by a blue matter, which acids change to red; and alkalies

* Liebig's Agricultural Chemistry.

and their carbonates, first to green, and then to yellow. The coloring matter of the violet exists in the petals of red clover, the red tips of the common daisy of the field, of the blue hyacinth, the hollyhock, lavender, in the inner leaves of the artichoke, and numerous other flowers. The same substance made red by an acid, colors the skin of several kinds of plums; probably, also, gives the red color to the petals of the scarlet geranium, and of the pomegranate tree. The leaves of the red cabbage, and the rind of the long radish, are also colored by this principle. It is remarkable that these, on being merely bruised, become blue, and give a blue infusion with water. It is probable that the reddening acid in these cases is the carbonic, which, on the rupture of the vessel which encloses it, (being a gas,) escapes into the atmosphere. If the petals of the red rose be triturated with a little water and chalk, a blue liquid is obtained. Alkalies render this blue liquid green, and acids restore its red color."*

Many attempts have been made to transfer the coloring matter of flowers to cloth, but without success. In general, they are so fugitive, as to change the moment they are brought into contact with the atmosphere, and those of them which can be extracted, have no affinity for the cloth. If a third substance be used to give this affinity, it destroys the original color of the vegetable. This is the case with nearly all vegetable coloring matter; for, if we except indigo, there is scarcely another substance which is capable of imparting its own color to cloth. Again, the coloring matter of flowers is very limited in its changing hues by artificial means. Acids change it to red, and alkalies to green, but these substances, though they thus act upon the coloring matter of vegetables, cannot serve as bonds of union between the color and the cloth with which they do not themselves possess the property of combining. The substances which act the part of intermedia to the vegetable coloring matters used in dyeing, do not affect or combine with the coloring substances. This property of combining with mordants, no doubt depends upon

* See Appendix, article *Experiments and Observations on Light.*

the chemical composition of the color, and the effects produced by these colors being in union with other substances which combine with the mordant upon the cloth. These substances are tannin and gallic acid, and so far as our observations extend, it is to the presence of one of these that most dyewoods owe their dyeing properties. At all events, the great variety of hues which they are capable of imparting to goods when combined with the oxides of the metals, are dependent upon these principles.

We are now about entering a field which is yet spacious, offering an ample harvest for the *practical* man who may combine a little science with his practice.

CHAPTER III.

ANIMAL AND VEGETABLE COLORING SUBSTANCES, WITH THEIR ORIGIN, USES, AND PRINCIPAL CHEMICAL CHARACTERS, &c.

Practical observations on Lichens—Anotta—Archil—Barwood—Bark (Quercitron)—Berries of Avignon—Brazil-wood—Camwood—Carmine, and the various processes of Manufacturing it—Carthamus (Safflower)—Catechue—Cochineal, and its Coloring principle—Cudbear—Fustic—Garancine—Hematine—Indigo, and its Manufacture—Mistaken notions of Dr. Ure on this subject—Kermes—Lac, Lac Dye—Lakes—Red Lakes—Carminated Lakes—Madder Lakes—Brazil-wood Lakes—Yellow Lakes—Litmus—Logwood—Madder—Madder Purple—Madder Red—Madder Orange—Madder Yellow—Madder Brown—Brands of Casks, and Adulteration of Madder by Mineral and Vegetable substances—On the determination of the Coloring power by the Colorimeter, Dyeing, &c.—Nicaragua-wood—Peachwood—Quercitron—Redwood—Safflower—Sandal, or Red Saunders-wood—Sapan-wood—Sumach—Turmeric—Turnsole—Weld—Woad—Extracting Coloring Matter from Dyewoods.

In order to form an exact idea of the effects produced by the substances employed in dyeing, their chemical properties must be known. We shall, therefore, in this and the two following chapters, present a summary view of the properties of the substances most commonly used in dyeing and calico-printing; stating, at the same time, the general principles which may serve to explain their action; and we shall so order it, that those persons who have but a limited acquaintance with chemistry, may find in this summary the most useful notions, and that those who are further advanced in the speculations of the science may perceive the relations connecting the particular phenomena to the general laws of combination.

According to the arrangement we have adopted we shall first treat of *animal* and *vegetable* coloring substances; secondly, of *mineral* coloring substances; and lastly, of *acids*.

Our knowledge concerning that department of organic chemistry which embraces the coloring matters, and other principles nearly allied to them, is of the most imperfect kind. Though many other branches of organic chemistry have been so thoroughly and accurately investigated, that little or nothing remains to be known concerning them, this may be called an unexplored field. Most of the coloring matters are so little known, as regards even their most essential characters, as not to allow us either to justify, or to question, the propriety of throwing them together into one general class; a class distinguished from those nearly allied to it merely by the (as far as we know) adventitious circumstance of the substances belonging to it, being endowed with certain more or less vivid colors. Among all the coloring matters, there are none, the study of whose properties and reactions is calculated to throw more light on the nature of the whole class, *than those which are prepared, by an artificial process, from certain kinds of lichens*, and on this account it is desirable that they should be carefully examined. It was the circumstance of these substances being prepared artificially from plants perfectly devoid of color, that first attracted to them the attention of chemists, and led to a series of investigations by which a number of highly interesting substances were brought to light, and a process elucidated which belongs to the most remarkable and unparalleled in the whole range of organic chemistry.

Robiquet first discovered a colorless crystalizable substance in them (orcin,) capable of being converted by the joint action of ammonia and oxygen into a true coloring matter, which contains neither the original substance, nor ammonia as such. This interesting discovery was followed by others. The researches of Heeren made us acquainted with a series of substances contained in the *Roccella tinctoria*, possessed of the same property, and another substance, phloridzin, was shown, by Stas, to bear a complete analogy to orcin, in this respect. The subsequent labors of Dumas, who subjected orcin, and the bodies derived from it, to an accurate examination, and of Kane, who has determined the composition of

the substances discovered by Heeren, and of the coloring matters contained in archil and litmus, seemed to have sufficiently elucidated the subject. Some obscurities, however, in a part of Dr. Kane's late paper, seemed to make it desirable that some of his results should be confirmed before being finally adopted; and, at the suggestion of Professor Liebig, Edward Schunck, Esq., of Manchester, undertook the investigation of this subject, and performed it in the Professor's laboratory.

Instead of the *Roccella tinctoria*, he employed in his experiments, the lichens that grow on the basalt rocks of the Vogelsberg, in Upper Hessia, where they are collected for the purpose of preparing a dye from them. These lichens were all crustaceous, and belonged to the genera *Lecanora*, *Urceolaria*, *Variolario*, &c. From them Mr. Schunck extracted the following substances:—

1. A white, crystaline substance, soluble in alcohol and ether, but insoluble in water, bearing in its properties great resemblance to the substance called by Heeren *Erythrin*, and by Kane *Erythrilin*, but different in composition, and giving other products of decomposition. This substance he calls *Lecanorin*.

2. A crystalizable substance identical in properties and composition with Heeren's *Pseuderythrin*, and Kane's *Erythrilin*.

3. A fatty substance of acid properties, soluble in alcohol, but insoluble in ether and water.*

The method by which these substances were extracted, and separated from one another, was the following:—

The lichens were reduced to a coarse powder, and then treated with ether, in an apparatus of displacement, until the

* This *fatty substance* has been examined but slightly. It is soluble in alcohol, but insoluble in ether and water. From an alcoholic solution it is deposited in small pearly-white scales; if the solution be spontaneously evaporated, it is obtained in small, hard, shining, transparent crystals. It is soluble in alkalies, forming soapy solutions, and is reprecipitated by acids. Its alkaline solutions do not become colored when exposed to the air. It cannot be melted without being decomposed.

ether dissolved nothing more. The ethereal extract, which had acquired a green tinge from chlorophyl in solution, was distilled off, leaving as a residue a greenish yellow mass, consisting, for the greater part, of lecanorin. This mass was brought into a glass funnel, and washed with small quantities of ether, until it had lost its green color in part. It was then treated with boiling water, in order to remove every trace of pseuderythrin, and, lastly, purified by dissolving it in a small quantity of boiling alcohol, which deposited, on cooling, a snow-white crystaline mass, consisting of lacanorin in a state of purity. The dark green ethereal fluid obtained by washing the impure lecanorin, contained, besides lecanorin, the greatest part of the pseuderythrin which had been extracted by the ether. The fluid was evaporated to dryness, and the residual mass treated with boiling water, which deposited, on cooling, a mass of shining plates and needles of pseuderythrin, which was purified by recrystalization. More of this substance was obtained by treating the lichens, which had been exhausted with ether, with boiling alcohol, and filtering rapidly. The alcohol was distilled off, and the residue treated with boiling water, which dissolved all the pseuderythrin, and deposited it on cooling. The mass left undissolved was washed with ether, which dissolved all the chlorophyl, and left behind the fatty substance mentioned above, which was purified by redissolving in alcohol.

A more minute description of the properties of these several bodies will now be given.

Lecanorin.—This substance, when pure, is perfectly white. If prepared in the manner described above, it has the appearance of a white mass, composed of acicular needles. When its solutions are slowly evaporated, it crystalizes in silky needles grouped together in star-shaped masses. It is insoluble in boiling water, but soluble easily in alcohol and ether. Its solutions redden litmus paper. It is soluble in alkaline liquors, from which it is precipitated unchanged by acids, provided the solutions be not boiled, and be not left to stand too long. It is insoluble in all weak acids, with the exception of acetic acid. Strong nitric acid converts it ultimately into

oxalic acid. It combines with metallic oxides by double decomposition. Heated on platinum foil it melts, emits a dense vapor, and burns off, leaving but little carbonaceous residue. When heated in a tube closed at one end, it melts, and, under violent ebullition, gives off a dense vapor, which condenses in the upper part of the tube into a thick liquid, which after some time solidifies, forming a crystaline mass. The nature of this sublimate will be explained further on.

The action of the alkalies on this substance, is, of course, the most interesting point connected with its history. A solution of lecanorin in ammonia, when exposed to the air, acquires, after some time, a beautiful deep purple color: from this solution acids precipitate a red coloring matter. A solution in potash, under the same circumstances, becomes of a deep red color. Being desirous of ascertaining whether the lecanorin was immediately converted into the red coloring matter, or whether it passed first into any intermediate state, which was not improbable, Mr. Schunck dissolved some of the substance in ammonia, excluding the solution from contact with the air. After a lapse of some hours, the solution, though perfectly colorless, was found no longer to contain any lecanorin; for acids instead of producing a thick gelatinous, or floculent, precipitate, as they do when applied immediately after the solution has been effected, merely caused a brisk effervescence of carbonic acid, plainly showing that the substance had been completely decomposed without a coloring matter having been formed. The same effect was brought about instantaneously when the solution was boiled. In order to observe the process more clearly, he dissolved a quantity of lecanorin in baryta water in the cold. The solution on being boiled, or allowed to stand, deposited a great mass of pure carbonate of baryta precipitated by a stream of carbonic acid: on slow evaporation, it yielded large prismatic crystals of a substance which possessed characters in every respect identical with those of *orcin*. It had an extremely sweet taste, was capable of being volatilized without change, and without leaving any residue; gave a deep blue color when dissolved in ammonia, and exposed to the air, struck a blood-

red color with nitric acid, and precipitated a solution of basic acetate of lead. Lecanorin thus is converted, by the action of alkalies, into orcin and carbonic acid, in the first instance, this decomposition always preceding the formation of coloring matters. The same decomposition is produced by the carbonated alkalies, by long boiling with water, and by dry distillation, the heavy vapor, mentioned above as being produced by heating lecanorin to decomposition, being vapor of orcin.

The composition of lecanorin is expressed by the formula $C_{18} H_8 O_8$. The results of the combustions which Mr. Schunck made of it, admit of no interpretation. All attempts to determine its atomic weight by means of combining it with metallic oxides, failed. These compounds can only be prepared by double decomposition; but the facility with which lecanorin is decomposed, when alkalies are added to its solutions, always renders the purity of the compounds formed liable to doubt. The compound with oxide of silver, formed by adding nitrate of silver to an alcoholic solution of lecanorin, and then precipitating by means of a few drops of ammonia, though it changed color but slightly in drying, gave no consistent results. The compound with oxide of lead, formed by precipitating a solution of lecanorin with basic acetate of lead, was so basic, and its formula so unusual, that Mr. Schunck was led to suppose that one or two atoms of basic acetate of lead were precipitated together with it. By decomposing, however, a weighted quantity of lecanorin with caustic baryta, and determining the quantity of carbonate of baryta formed, very accurate results were obtained, confirming the formula $C_9 H_4 O_4$, or $C_{18} H_8 O_8$, for lecanorin. In regard to the composition of orcin, the same gentleman was induced to replace the generally received formula, for its composition, by a new one. Dumas' formula for anhydrous orcin is $C_{16} H_7 O_3$, and for crystalized orcin $C_{16} H_{12} O_8$, which evidently cannot be brought into accordance with the formula for lecanorin as given above. If, however, the formula $C_{16} H_6 O_2$, be taken for anhydrous orcin, and $C_{16} H_{11} O_7$ for crystalized orcin, then the decomposition which lecanorin undergoes with alkalies, may be expressed as follows:—

1 atom of anhydrous orcin,	$C_{16}\ H_6\ O_2$
2 atoms of water,	$H_2\ O_2$
2 atoms of carbonic acid,	$C_2\ \ O_4$
1 atom of lecanorin,	$C_{18}\ H_8\ O_8$

Two atoms of water are furnished by the decomposition of the lecanorin itself, and three more by the fluid, to form from $C_{16}\ H_6\ O_2$ one atom of crystalized orcin, $C_{16}\ H_{11}\ O_7$. The combustions made of this substance by Mr. Schunck, agree perfectly with these formulas, but Dumas' analysis of the lead compound of orcin, do not coincide with them, unless it be supposed that this compound contains acetate of lead, either in chemical combination, or mechanically mixed.

From what has been said, it is evident that our knowledge of this series of bodies is far from being complete. It has been shown above, that the action of alkalies on lecanorin is two-fold; it consists, first, in abstracting from the substance carbonic acid, a process not requiring the co-operation of the oxygen of the atmosphere; secondly, in inducing, in contact with the air, the formation of coloring matters. The first action seems to have been overlooked in the case of all the bodies nearly allied to lecanorin. Mr. Schunck found the most complete analogy in the case of Heeren's pseuderythrin; "and if," says he, "I am not mistaken in the interpretation of his statements, his erythrin also undergoes the same decomposition as lecanorin, for the former is converted into erythrin-bitter, by the very same agencies by which lecanorin is converted into orcin, and, in fact, there is the same relation in regard to all general properties between erythrin and erythrin-bitter, as between lecanorin and orcin." This circumstance is of some importance, for, in order to arrive at a knowledge of the exact composition of such complex bodies as the coloring matters formed by the action of alkalies on these substances, and to understand perfectly the nature of the process by which they are produced, it is absolutely necessary to know the exact substance out of which each is in the last instance formed, the last link of the chain which precedes its formation.

Pseuderythrin.—For this substance it would be advisable

to substitute another name, as, in this case, the substance by which it is accompanied is not erythrin but lecanorin. It is contained in very small quantities of lichens that have been examined. It is sparingly soluble in cold water, from which it crystalizes, on cooling, in shining plates and needles. If more of the substance is taken than the boiling water can dissolve, the part left undissolved melts and collects at the bottom of the fluid in oily drops, which, on the temperature falling a little below 212, congeal, and form crystaline masses. This is a characteristic property of pseuderythrin, and one distinctly mentioned by Heeren. It is easily soluble in alcohol and ether, and also in alkaline solutions. It gives compounds with metallic oxides by double decomposition. When dissolved in ammonia, and exposed to the air, it gives, like lecanorin, a red coloring matter; but its conversion into the latter is much more slowly effected than that of lecanorin. When subjected to dry distillation, it also gives a crystaline sublimate, accompanied by a copious disengagement of gas. When its solution in an alkali is boiled, or left to stand some time, it imparts carbonic acid to the alkali, the decomposition being accomplished, however, with much more difficulty than with lecanorin. The exact nature of the substance left in solution, after this decomposition.

A.

ANOTTA.—This substance is obtained from a shrub originally a native of South America, and now cultivated in Guiana, St. Domingo, and the East Indies. It is termed the *Anotta tree*, or *Bixa orellana*. It seldom attains to more than twelve feet in height, the leaves are divided by fibres of a reddish-brown color, they are four inches long, broad at the base, and tend to a sharp point. The stem has likewise fibres which in Jamaica are converted into serviceable ropes.

"The tree produces oblong bristled pods, somewhat resembling those of a chestnut; these are at first of a beautiful rose-color, but as they ripen, change to a dark-brown, and bursting

open, display a splendid crimson farina or pulp,* in which are contained from thirty to forty seeds somewhat resembling raisin stones. As soon as they have arrived at maturity, these pods are gathered, divested of their husks, and bruised. Their pulpy substance, which seems to be the only part which constitutes the dye, is then put into a cistern, with just enough water to cover it, and in this situation it remains for seven or eight days, or until the liquor begins to ferment, which sometimes requires as many weeks, according to circumstances. It is then strongly agitated with wooden paddles and beaters, to promote the separation of the pulp from the seeds, this operation is continued until these have no longer any coloring matter adhering to them. The liquor is then passed through a sieve, and afterwards boiled, the coloring matter being thrown to the surface in the form of scum, or otherwise allowed to subside; in either case it is boiled in coppers till reduced to a paste, when it is made up into cakes and dried."†

Another and more preferable mode of extracting the coloring matter from these seeds, is rubbing them one against another under water, so that the mucilaginous and other impure matters contained in the interior of the seeds are not mixed with it. When extracted in this way, the coloring matter is allowed to settle, the water drawn off, and the anotta left to dry. When prepared in this manner it has a fatty feel, and is very homogeneous and of a deep red color, which changes to a dark-brown by drying; it has no taste, but generally a disagreeable smell, which is not natural, but owing to stale urine having been added to it, for the purpose of improving its color and keeping it moist.

1. Muriatic acid has no action upon anotta.
2. Chlorine discolors it.

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* Dr. John found in the pulp surrounding the unfermented fresh seeds, which are about the size of little peas, 28 parts of coloring resinous matter, 26.5 of vegetable gluten, 20 of ligneous fibre, 20 of coloring extractive matter, 4 formed of matters analogous to vegetable gluten, and extractive, and a trace of spices and acid matters. When anotta is used in calico-printing, it is usually mixed with potash or ammonia and starch.

† Ann. de Chim. Tom. 47.

3. Nitric acid completely decomposes it, giving rise to several chemical compounds which have not been investigated.

4. Sulphuric acid poured upon it in the solid, gives it a deep blue color like indigo, which changes into a dark dirty green, and then to a blackish purple.—(See Red, Orange, and Yellow Dyes, Parts III. and V.)

ARCHIL.—A violet red paste used in dyeing, of which the substance called cudbear, in Scotland (from *Cuthbert*, its first preparer in that form), is a modification. Two kinds of archil are distinguished in commerce, the *archil* plant of the Canaries, and that of Auvergne. The first is most esteemed: it is prepared from the *lichen rocellus*, which grows on rocks adjoining the sea in the Canary and Cape de Verd Islands, in Sardinia, Minorca, &c., as well as on the rocks of Sweden. The second species is prepared from the *lichen parellus*, which grows on the basaltic rocks of Auvergne.

There are several other species of lichen which might be employed in producing an analogous dye, were they prepared, like the preceding, into the substance called *archil*. Hellot gives the following method for discovering if they possess this property.* A little of the plant is to be put into a glass vessel; it is to be moistened with ammonia and lime-water in equal parts; a little muriate of ammonia (sal ammoniac) is added; and the small vessel is corked. If the plant be of a nature to afford a red dye, after three or four days, the small portion of liquid, which will run off on inclining the vessel, now opened, will be tinged of a crimson red, and the plant itself will have assumed this color. If the liquor or the plant does not take this color, nothing need be hoped for; and it is useless to attempt its preparation on the great scale. Lewis says, however, that he has tested in this way a great many mosses, and that most of them afforded him a yellow or reddish-brown color; but that he obtained from only a small number a liquor of a deep red, which communicated to cloth merely a yellowish-red color.†

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* Berthollet, vol. II., page 184.

† The Chemical Works of Gaspard Neuman.

Prepared archil gives out its color very readily to water, ammonia, and alcohol. Its solution in alcohol is used for filling spirit-of-wine thermometers; and when these thermometers are well freed from air, the liquor loses its color in some years, as Abbé Nollet observed.* The contact of air restores the color, which is destroyed anew, in vacuo, in process of time. The watery infusion loses its color, by the privation of air, in a few days; a singular phenomenon, which merits new researches.

The infusion of archil is, says M. Berthollet,† of a crimson bordering on violet. As it contains ammonia, which has already modified its natural color, the fixed alkalies can produce little change on it, only deepening the color a little, and making it more violet. Alum forms in it a precipitate of brown red; and the supernatant liquid retains a yellowish-red color. The solution of tin affords a reddish precipitate, which falls down slowly; the supernatant liquid retains a feeble red color. The other metallic salts produce precipitates which offer nothing remarkable.

To dye with archil, says Berthollet, the quantity of this substance deemed necessary, according to the quantity of wool or stuff to be dyed, and according to the shade to which they are to be brought, is to be diffused in a bath of water as soon as it begins to grow warm. The bath is then heated till it be ready to boil, and the wool or stuff is passed through it without any other preparation, except keeping that longest in, which is to have the deepest shade. A fine gridelin, bordering upon violet, is thereby obtained; but this color has no permanence. Hence archil is rarely employed with any other view than to modify, heighten, and give lustre to the other colors. Hellot says, that having employed archil on wool boiled with tartar and alum, the color resisted the air no more than that which had received no mordant. But he obtained from herb archil (*l'orseille d'herbe*) a much more durable color, by putting in the bath some solution of tin. The archil thereby loses its natural color, and assumes one approaching

* Mém. de l'Acad. 1742.

† Vol. II. p. 185.

more or less to scarlet, according to the quantity of solution of tin employed. This process must be executed in nearly the same manner as that of scarlet, except that the dyeing may be performed in a single bath.

Archil is frequently had recourse to for varying the different shades and giving them lustre; hence it is used for violets, lilacs, mallows, and rosemary flowers. To obtain a deeper tone, sometimes a little alkali or milk of lime is mixed with it. The suites of this browning may also afford agates, rosemary flowers, and other delicate colors, which cannot be obtained so beautiful by other processes. Alum cannot be substituted for this purpose; it not only does not give this lustre, but it degrades the deep colors.

The herb-archil is preferable to the archil of Auvergne, from the greater bloom which it communicates to the colors, and from the larger quantity of coloring matter. It has, besides, the advantage of bearing ebullition. The latter, moreover, does not answer with alum, which destroys the color; but the herb archil has the inconvenience of dyeing in an irregular manner, unless attention be given to pass the cloth through hot water as soon as it comes out of the dye.

Archil alone is not used for dyeing silk, unless for lilacs; but silk is frequently passed through a bath of archil, either before dyeing it in other baths or after it has been dyed, in order to modify different colors, or to give them lustre. Examples of this will be given in treating of the compound colors. It is sufficient here to point out how white silks are passed through the archil bath. The same process is performed with a bath more or less charged with this color, for silks already dyed.*

Archil is in general a very useful ingredient in dyeing; but as it is rich in color, and communicates an alluring bloom, dyers are often tempted to abuse it, and to exceed the proportions that can add to the beauty without at the same time injuring in a dangerous manner the permanence of the colors. Nevertheless, the color obtained when solution of tin is em-

* See Silk Dyeing, Part V.

ployed, is less fugitive than without this addition: it is red, approaching to scarlet. Tin appears to be the only ingredient which can increase its durability. The solution of tin may be employed, not only in the dyeing bath, but for the preparation of the silk. In this case, by mixing the archil with other coloring substances, dyes may be obtained which have lustre with sufficient durability.*

We have spoken of the color of archil, says Berthollet, as if it were natural to it; but it is, really, due to an alkaline combination. The acids make it pass to red, either by saturating the alkali, or by substituting themselves for the alkali.

The lichen which produces archil is subjected to another preparation, to make turnsole (litmus). This article is made in Holland. The lichen comes from the Canary Islands, and also from Sweden. It is reduced to a fine powder by means of a mill, and a certain proportion of potash is mixed with it. The mixture is watered with urine, and allowed to suffer a species of fermentation. When this has arrived at a certain degree, carbonate of lime in powder is added, to give consistence and weight to the paste, which is afterwards reduced into small parallelopipeds that are carefully dried.†

Westring, of Stockholm, examined 150 species of lichens, among which he found several that might be rendered useful; but in his time this subject was not thoroughly understood, as we have shown in the first part of this chapter. He recommends that the coloring matter should be extracted in the places where they grow, which would save a vast expense in curing, package, carriage, and waste. He styles the coloring substance itself cudbear, persio, or turnsole; and distributes the lichens as follows:—1st. Those which, left to themselves, exposed to moderate heat and moisture, may be fixed without a mordant upon wool or silk: such are the L. *cinereus*,

* The watery solution of archil, applied to cold marble, penetrates it, communicating a beautiful violet color, or a blue bordering on purple, which resists the air much longer than the archil colors applied to other substances. Dufay says *that he has seen marble tinged with this color preserve it without alteration at the end of two years.*

† Journal des Arts et Manufactures, tom. II.

æmatonta, ventosus, corallinus, westringii, saxatilis, conspassus, barbatus, plicatus, vulpinus, &c.

2. Those which develop a coloring matter, fixable likewise without mordant, but which require boiling and a complicated preparation; such are the lichens *subcarneus, dillenii, farinaceus, jubatus, furfuraceus, pulmonareus, cornigatus, cocciferus, digitutas, ancialis, aduncus*, &c. Saltpetre or sea-salt is requisite to improve the lustre and fastness of the dye given by this group to silk.

3. Those which require a peculiar process to develop their color; such as those which become purple through the agency of stale urine or ammonia. Westring employed the following mode of testing:—

He put 3 or 4 drachms of the dried and powdered lichen into a flask; moistened it with three or four measures of cold spring water; put the stuff to be dyed into the mixture, and left the flask in a cool place. Sometimes he added a little salt, saltpetre, quicklime, or sulphate of copper. If no color appeared, he then moistened the lichen with water containing one-twentieth of sal ammoniac, and one-tenth of quicklime, and set the mixture aside in a cool place from eight to fourteen days. There appeared, in most cases, a reddish or violet colored tint.

Thus the *lichen cinercus* dyed silk a deep carmelite, and wool a light carmelite; the *l. physodes* gave a yellowish-gray; the *pustulatus*, a rose red; *sanguinarius*, gray; *tartareus*, found on the rocks of Norway, Scotland, and England, dyes a crimson-red. In Jutland, cudbear is made from it, by grinding the dry lichen, sifting it, then setting it to ferment in a close vessel with ammonia. The lichen must be of the third year's growth to yield an abundant dye; and that which grows near the sea is the best. It loses half its weight by drying. A single person may gather from twenty to thirty pounds a day in situations where it abounds. No less than 2,239,685 pounds were manufactured at Christiansand, Flekkefiort, and Fakrsund, in Norway, in the course of the six years prior to 1812. Since more solid dyes of the same shade have been invented, the archil has gone much into disuse. Federigo, of Florence, who revived its use at the beginning of the fourteenth century, made such an immense fortune by its preparation, that his family became one of the grandees of that city,

under the name of Oricellarii, or Rucellarii. For more than a century, Italy possessed the exclusive art of making archil, obtaining the lichens from the islands of the Mediterranean.—(See *Litmus.*)

B

BARWOOD.—This is a wood of which *no good chemical description* has yet appeared. As a dyewood, it possesses many peculiar properties, and is also becoming extensively useful in the dye-house. It contains a very great quantity of coloring matter, but is very slightly soluble in water. This difficulty is overcome by the following very ingenious arrangement:—

The coloring matter, while hot, combines easily with the proto-compounds of tin, forming an insoluble cake of a rich red color; the goods to be dyed are impregnated with a proto-chloride of tin, combined with sumac; the proper proportion of barwood for the color wanted is put into a boiler and brought to boil; the goods thus impregnated are put into this boiling water containing the rasped wood, and the small portion of coloring matter dissolved in the water is immediately taken up by the goods. The water, thus exhausted, dissolves a new portion of coloring matter, which is again taken up by the goods, and so on till the tin upon the cloth has become saturated.

A good deal of attention and skill is necessary to know the exact point to take the goods out of the bath, otherwise the dyer may either have the color poor, or by being in too long, give it a brown color. It is not, therefore, every dyer who can dye good barwood red. Barwood cannot be used for any composition color in the same manner as the other red woods are, probably owing to the little quantity of coloring matter which water dissolves from it.—(See chapter I, Part III, article *Barwood Red Spirits*, and chapter III, of the same Part, article *Barwood Red.*

BARK.—(See *Quercitron.*)

BERRIES OF AVIGNON, *and Persian Berries.*—A yellow dye-drug, the fruit of the *rhamnus infectorius*, a plant cultivated in Provence, Languedoc, and Dauphine, for the sake of its berries, which are plucked before they are ripe, while they have a greenish hue. Another variety comes

from Persia; it is larger than the French kind, and has superior properties. The principal substances contained in these berries are, 1. A coloring matter, which is united with a matter insoluble in ether, little soluble in concentrated alcohol, and very soluble in water: it appears to be volatile. 2. A matter remarkable for its bitterness, which is soluble in water and alcohol. 3. A third principle, in small quantity. A decoction of one part of the Avignon or Persian berry in ten of water, affords a brown-yellow liquor bordering upon green, having the smell of a vegetable extract, and a slightly bitter taste.

With gelatine that decoction gives, after some time, a slight precipitate,—

With	alkalis - - -	a yellow hue,
—	acids - - -	a slight muddiness,
—	lime-water - -	a greenish-yellow tint,
—	alum - - -	a yellow color,
—	red sulphate of iron -	an olive-green color,
—	sulphate of copper -	an olive color,
—	proto-muriate of tin	a greenish-yellow with a slight precipitate.*

BRAZIL-WOOD.—This dyewood derives its name from the part of America whence it was first imported. It has also the name Pernambuco, wood of Saint Martha, and of Sapan, according to the places which produce it. Linnæus distinguishes the tree which produces the Brazil-wood by the name of *Cæsalpinia crista*. It commonly grows in dry places among rocks.† Its trunk is very large, crooked, and full of

* Ure's Dictionary of Arts, Manufactures, &c., vol. i., p. 124.

† The *ibiripitanga*, or Brazil-wood, called in Pernambuco, the *pao da rainha* (Queen's wood), on account of its being a government monopoly, is now rarely to be seen within many leagues of the coast, owing to the improvident manner in which it has been cut down by the government agents, without any regard being paid to the size of the tree or to its cultivation. It is not a lofty tree. At a short distance from the ground, innumerable branches spring forth, and extend in every direction in a straggling and unpleasing manner. The leaves are small, and not luxuriant; the wood is very hard and heavy, takes a high polish, and sinks in water; the only valuable portion of it is the heart, as the outward coat of wood has not any peculiarity. The name of this wood is derived from *Crasas*, a glow-

knots. It is very hard, susceptible of a fine polish, and sinks in water. It is pale when newly cleft, but becomes red on exposure to the air. It has different shades of red and orange. Its goodness is determined particularly by its density. When chewed, a saccharine taste is perceived. It may be distinguished from red saunders wood, as the latter does not yield its color to water.

According to Dufay, a red color, passing into violet, may be given by the alcohol of Brazil-wood to heated marble. If the heat be increased while the stained marbles are coated with wax, the color runs through all the shades of brown, and settles into a chocolate. Berthollet's, Dingler's, Guliche's, and Poerner's observations on this wood are of no consequence to the practical man, at the present day. For the best method of extracting the coloring matter, and dyeing with it, see chapter III., Part III., article *Brazil-wood Red*, and the close of this chapter, article, *Extracting Coloring Matter from Dyewoods.*

C.

CAMWOOD may be ranked with the Brazil-woods, as it possesses similar dyeing properties. It is imported from Sierra Leone, and is very extensively used in the dye-house.

Though Camwood may be ranked amongst the Brazil-woods, being used in the dye-house for the same purposes, the color from it is more permanent, and in many instances the color obtained is much more beautiful. The precipitates from a decoction of the wood are more yellow than the Brazil-woods, which give the colors dyed by it a certain degree of richness not obtained with the other woods. It is not so easily affected by alkaline substances, and appears to contain more tannin than the Brazil-woods. With it (Camwood) the following are some of the results of a series of experiments which,

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ing fire or coal—its botanical name is *Cæsalpinia Crasileto.* The leaves are pinnated; the flowers white and papilionaceous, growing in a pyramidal spike; one species has flowers variegated with red. The branches are slender and full of small prickles. There are nine species.—*Bell's Geography.*

a friend of ours, a celebrated calico-printer, recently instituted:—

1. Protosulphate of iron, gives a brownish black precipitate.
2. Persulphate, a reddish brown.
3. Protosalts of tin give the solution a very bright carmine red color, but little precipitate.
4. Lead salts, a rich orange precipitate after standing some time.
5. Acetate of copper gives a light reddish brown.
6. Nitrate of silver, a reddish-yellow precipitate.
7. Perchloride of mercury, a light orange by standing.
8. Alum gives the solution a beautiful red color.

This wood may also be used for browns and other composition colors where Brazil-wood is commonly used; it is more soluble in water, and has other advantageous properties which bid fair to render it a substitute for many purposes in which the best Brazil-woods are now employed.—(See chapter I., Part III., and chapter IV., Part IV.)

CARMINE* is, according to Pellettier and Cevanton, a triple compound of the coloring substance, and an animal matter contained in cochineal, combined with an acid added to effect the precipitation. The preparation of this article is still a mystery, because, upon the one hand, its consumption being very limited, few persons are engaged in its manufacture, and upon the other, the raw material being costly, extensive experiments on it cannot be conveniently made. Success in this business is said to depend not a little upon dexterity of manipulation, and upon knowing the instant for arresting the further action of heat upon the materials.

There is sold at the shops different kinds of carmine, distinguished by numbers, and possessed of a corresponding value. This difference depends upon two causes; either upon the proportion of alumina added in the precipitation, or of a certain quantity of vermilion put in to dilute the color. In the first case the shade is paler, in the second it has not the same lustre. It is always easy to discover the proportion of the adulteration. By availing ourselves of the property of pure carmine to dissolve in water of ammonia, the whole

* See *Cochineal.*

foreign matter remains untouched, and we may estimate its amount by drying the residuum. To make ordinary carmine, proceed as follows:—

Take 1 pound of cochineal in powder;
3 drachms and a half of carbonate of potash;
8 drachms of alum in powder;
3 drachms and a half of fish-glue.

The cochineal must be boiled along with the potash in a copper containing five pailsful of water (60 pints); the ebullition being allayed with cold water. After boiling a few minutes the copper must be taken from the fire, and placed on a table at such an angle as that the liquor may be conveniently transvased. The pounded alum is then thrown in, and the decoction is stirred; it changes color immediately, and inclines to a more brilliant tint. At the end of fifteen minutes the cochineal is deposited at the bottom, and the bath becomes as clear as if it had been filtered. It contains the coloring matter, and probably a little alum in suspension. We decant it then into a copper of equal capacity, and place it over the fire, adding the fish-glue dissolved in a great deal of water, and passed through a searce. At the moment of ebullition, the carmine is perceived to rise up to the surface of the bath, and a coagulum is formed, like what takes place in clarifications with white of egg. The copper must be immediately taken from the fire, and its contents be stirred with a spatula. In the course of fifteen or twenty minutes the carmine is deposited. The supernatant liquor is decanted, and the deposite must be drained upon a filter of fine canvass or linen. If the operation has been well conducted, the carmine, when dry, crushes readily under the fingers. What remains after the precipitation of the carmine is still much loaded with color, and may be employed very advantageously for carminated lakes.—(See *Lake.*)

By the *old German process*, carmine is prepared by means of alum without any other addition. As soon as the water boils, the powdered cochineal is thrown into it, stirred well, and then boiled for six minutes; a little ground alum is added, and the boiling is continued for three minutes more;

the vessel is removed from the fire, the liquor is filtered and left for three days in porcelain vessels, in the course of which time a red matter falls down, which must be separated and dried in the shade. This is carmine, which is sometimes previously purified by washing. The liquor after three days more lets fall an inferior kind of carmine, but the residuary coloring matter may also be separated by the muriate of tin.*

The proportions for the above process are 580 parts of clear river water, 16 parts of cochineal, and 1 part of alum; there is obtained from 1½ to 2 parts of carmine.

Another *carmine with tartar*.—To the boiling water the cochineal is added, and after some time a little cream of tartar; in eight minutes more we add a little alum, and continue the boiling for a minute or two longer. Then take it from the fire and pour it into glass or porcelain vessels, filter, and let it repose quietly till the carmine falls down. We then decant and dry in the shade. The proportions are 8 pounds of water, 8 oz. of cochineal, ½ oz. of cream of tartar, ¾ oz. of alum, and the product is an ounce of carmine.

The process of Alxon or Langlois.—Boil two pails and a half of river water (30 pints), throw into it, a little afterwards, a pound of cochineal, add a filtered solution of six drachms of carbonate of soda and a pound of water, and let the mixture boil for half an hour; remove the copper from the fire, and let it cool, inclining it to one side. Add six drachms of pulverized alum, stir with a brush to quicken the solution of the salt, and let the whole rest 20 minutes. The liquor, which has a fine scarlet color, is to be carefully decanted into another vessel, and there is to be put into it the whites of two eggs, well beat up, with half a pound of water. Stir again with a brush. The copper is replaced on a fire, the alumina becomes concrete, and carries down the coloring matter with it. The copper is to be taken from the fire, and left at rest for 25 or 30

* M. M. Pelletier and Caventon remark, that to obtain a beautiful shade, the muriate of tin ought to be entirely at the maximum of oxidizement; and it is in reality in this state that it must exist in the solution of tin prepared according to the proportions prescribed by Berthollet, in his work on dyeing.—(See chapter I, Part IV., *Mordant A.*)

minutes to allow the carmine to fall down. When the supernatant liquor is drawn off, the deposite is placed upon a filter cloth stretched upon a frame to drain. When the carmine has the consistence of cream cheese, it is taken from the filter with a silver or ivory knife, and set to dry upon plates covered with paper, to screen it from dust. A pound of cochineal gives in this way an ounce and a half of carmine.

Process of Madame Cenette, of Amsterdam, with salt of sorrel.—Into six pails of river water boiling hot throw two pounds of the finest cochineal in powder, continue the ebullition for two hours, and then add 3 oz. of refined saltpetre, and after a few minutes 4 oz. of salt of sorrel. In ten minutes more take the copper from the fire and let it settle for four hours; then draw off the liquor with a syphon into flat plates and leave it there for three weeks. Afterwards there is formed upon the surface a pretty thick mouldiness, which is to be removed dexterously in one pellicle by a slip of whalebone. Should the film tear and fragments of it fall down, they must be removed with the utmost care. Decant the supernatant water with a syphon, the end of which may touch the bottom of the vessel, because the layer of carmine is very firm. Whatever water remains must be sucked away by a pipette. The carmine is dried in the shade, and has an extraordinary lustre.

Carmine by the salt of tin, or the Carmine of China.—Boil the cochineal in river water, adding some Roman alum, then pass through a fine cloth to remove the cochineal, and set the liquor aside. It becomes brighter on keeping. After having heated this liquor, pour into it, drop by drop, solution of tin till the carmine be precipitated. The proportions are one pailful of water, 20 oz. of cochineal, and 60 grains of alum, with a solution of tin containing 4 oz. of the metal.

To revive or brighten Carmine.—We may brighten ordinary carmine, and obtain a very fine and clear pigment, by dissolving it in water of ammonia. For this purpose, we leave ammonia upon carmine in the heat of the sun, till all its color be extracted, and the liquor has got a fine red tinge. It must be then drawn off and precipitated, by acetic acid and alcohol,

next washed with alcohol, and dried. Carmine, dissolved in ammonia, has been long employed by painters, under the name of liquid carmine.* This valuable pigment is often adulterated with starch. Water of ammonia enables us to detect this fraud by dissolving the pure carmine, and leaving the starchy matter, as well as most other sophisticating substances. Such debased carmine is apt to spoil with damp.†

There occurs in commerce a kind of very fine colored and very expensive carmine, in the form of cakes, which owes its fine color to an adulteration. Upon being made use of for ordinary painting no difference has been observed; but by the microscope it may be discovered that half of it consists of starch (wheat starch), which imparts to the finely divided carmine a clear ground, and a brilliancy highly improving the appearance of the color. When such carmine is mixed with much water, it diffuses itself throughout, and is for a long time suspended; but upon pouring off the water a white sediment remains similar to white lead. The sediment is starch. Besides this distinct form and size of an amilaceous body, when it is examined by its reaction upon tincture of sodium, it produces the well-known blue color. This sediment, when heated with water, forms a paste. The addition of white lead is detected by its weight, but the addition of starch is not so easily discovered; but by means of the microscope, the adulteration may be with certainty recognized, and confirmed by chemical examination.

From the foregoing observations, it will be seen why, in dyeing scarlet, the employment of alum is carefully avoided, as this salt tends to convert the shade to a crimson. The presence of an alkali would seem less to be feared. The alkali would occasion, no doubt, a crimson-colored bath; but it would be easy in this case to restore the color, by using a larger quan-

* According to M. Von Grotthuss, carmine may be deprived of its golden shade by ammonia, and subsequent treatment with acetic acid and alcohol. Since this fact was made known, some beautiful carmines have been made.

† Carmine is the finest red color which the painter possesses. It is principally employed in miniature painting, water colors, and to tint artificial flowers, because it is more transparent than the other colors.

tity of tartar. We should, therefore, procure the advantage of having a bath better charged with coloring matter and animal substance. It is for experience on the large scale to determine this point. As to the earthy salts, they must be carefully avoided; and if the waters be selenitish, it would be a reason for adding a little alkali.

To obtain crimson, it is sufficient, as we know, to add alum to the cochineal bath, or to boil the scarlet cloth in alum water. It is also proper to diminish the dose of the salt of tin, since it is found to counteract the action of the alum. The alkalies ought to be rejected as a means of changing scarlet to crimson. In fact, crimsons prepared by this process cannot be permanent colors, as they pass into reds by the action of acids. —(See chapter I., Part IV., and chapter III., Part V., article *Crimson.*)

CARTHAMUS.—(See *Safflower.*)

CATECHUE.—This is a dry extract prepared from the wood of a species of sensitive plant named *acacia catachue.* This substance was long considered as an earth which was found in Japan; and was, consequently, called *terra Japanica.* Its true character was first pointed out by Mr. Kerr, who published a paper describing the process of obtaining and manufacturing it from the plant. This plant is indigenous to Hindostan, flourishing abundantly in mountainous parts. It grows to about twelve feet in height, and one foot in diameter, and is covered with a thick, rough, brown bark. The extract obtained from the tree is made from a decoction of the wood. As soon as the trees are felled, all the exterior white wood is carefully cut away, the interior or colored wood is then cut into chips; narrow mouthed unglazed pots are nearly filled with these, and water is added to cover them and reach to the top of the vessel. When this is half evaporated by boiling, the decoction without straining is poured into a shallow earthen vessel, and further reduced two-thirds by boiling. It is then set in a cool place for one day, and afterwards evaporated by the heat of the sun, being stirred several times during that process. When it is reduced to a considerable thickness it is spread upon a mat or cloth, which has been previously

covered with the ashes of cow-dung. This mass is divided with a string into quadrangular pieces, which are completely dried by being turned frequently in the sun, and are then fit for sale. It is a brittle, compact solid, of a dark brown or chocolate color; has no smell, but a very stringent taste; is soluble in water; contains a great amount of tannin, and a peculiar acid, which has been named catechuic acid; *it is the reaction of these, with oxygen and other chemical agents, that constitutes the dyeing properties.* A solution of catechue in water is a beautiful red-brown color, which will enable the reader to follow within his mind the action of the following re-agents with a solution of catechue in water:—

1. Acids brighten the colors of the solution.
2. Alkaline substances darken the solution which increases by standing.
3. Protosalts of iron gives an olive-brown precipitate.
4. Persalts of iron, olive-green with a brownish tint.
5. Nitrate and sulphate of copper, turn the liquor yellowish brown, giving a precipitate by a short exposure.
6. Acetate of copper a deep brown preciptate.
7. Salts of lead, salmon-colored precipitate.
8. Tin salts, brownish-yellow.
9. Bichromate of potash, deep red brown preciptate.

These precipitates are all insoluble, and have an attraction for vegetable and animal substances, so that catechue in the hands of the intelligent dyer becomes an agent of extensive application. It is but a few years since this substance was first introduced into the fancy dye-house, as an agent for dyeing *permanent browns* upon *cotton yarn.** Its introduction raised a considerable excitement throughout the trade, in Great Britain, but the parties who introduced it had not a long monopoly, from their giving the name of the new brown that of *catechue brown;* which at once betrayed their secret, and before long, catechue brown became quite common. But during the experiments to get at the method of dyeing brown, its application to many other colors became known, so that not only browns, but *fawns*, *drabs*, *olives*, and *blacks*, were all produced by catechue.

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* See chapter IX. Part III. article, *Catechue Brown.*

When catechue is dissolved in boiling water it has a gummy consistence, so that yarn cannot be dyed in it in this state. The addition of some metallic salt, such as the nitrate or sulphate of copper, sulphate of zinc, chloride of tin, &c. destroys the gummy principle, so that some one of these salts must be added previous to dyeing yarns by catechue. The chemical change which takes place on the addition of these salts is not well understood. The explanation generally given, is, that the salt added oxidizes the catechue, producing an insoluble oxide which, however, is soluble in a solution of catechue not oxidized, so that the salt added only oxidizes a part, which remains in solution in the portion not oxidized. We do not think this explanation is correct, because the oxidation of catechue is its conversion into another substance of a darker color; whereas the addition of a little nitrate of copper, for instance, renders the solution lighter, because the fixation of the color upon the yarns depends upon its oxidation, so that the portion oxidized before going upon the goods would neither alter in shade, nor produce a different shade from that it receives in the solution. As an instance of this, if into a solution of catechue in water there be put sulphate of zinc instead of nitrate of copper, a piece of cotton put into this receives a light buff or nankeen color; if this is now passed through a weak solution of lime, and then exposed to the air, it absorbs oxygen, and in a few hours becomes a dark permanent brown, little inferior to that dyed in the usual way. There is, however, no doubt that the addition of a metallic salt facilitates the oxidation of the catechue when upon the goods.

According to Dr. Ure,* a solution of one part of catechue in ten parts of water, which is reddish brown, exhibits the following results: with—

1. Acids - - - - -	A brightened shade.
2. Alkalis - - - - -	A darkened shade.
3. Proto-sulphate of iron - -	Olive brown precipitate.
4. Per-sulphate of iron - - -	Olive green do.
5. Sulphate of copper - - -	Yellowish brown.

* Dictionary of Arts, Manufactures, &c. vol. I., p. 227.

6.	Alum	A brightening of the liquor.
7.	Per-nitrate of iron	Olive green precipitate.
8.	Nitrate of copper	Yellowish brown do.
9.	Nitrate of lead	Salmon do.
10.	Proto-nitrate of mercury	Milk-coffee do.
11.	Muriate of alumina	Brown-yellow.
12.	Muriate of tin	Do. do.
13.	Per-chloride of tin	Do. darker.
14.	Corrosive sublimate	Light chocolate do.
15.	Acetate of alumina	Brightening of the liquor.
16.	Acetate of copper	Copious brown precipitate.
17.	Acetate of lead	Salmon colored do.
18.	Bichromate of potash	Copious brown do.

Good catechue, says Dr. Ure,* is a brittle compact solid, of a dull fracture. It has no smell, but a very astringent taste. Water dissolves the whole of it, except the earthy matter, which is probably added during its preparation. Alcohol dissolves its tannin and extractive. The latter may be oxidized, and thus rendered insoluble in alcohol, by dissolving the catechue in water, exposing it for some time to a boiling heat, and evaporating to dryness. The tannin of catechue differs from that of galls, in being soluble in alcohol, and more soluble in water. It precipitates iron of an olive color, and gelatin in a mass which gradually becomes brown.

COCHINEAL was taken in Europe at first for a seed, but was proved by the observations of Lewenhoeck to be an insect, being the female of that species of shield-louse, or *coccus*, discovered in Mexico, so long ago as 1518, where the animal lives upon the *cactus opuntia* or *nopal*. Two sorts of cochineal are gathered—the wild from the woods, called by the Spanish name *grana silvestra;* and the cultivated, or the *grana fina*, termed also *mesteque*, from the name of a Mexican province. The first is smaller, and covered with a cottony down, which increases its bulk with a matter useless in dyeing; it yields, therefore, in equal weight, much less color, and is of inferior price to that of the fine cochineal. But these disadvantages are compensated in some measure to the growers by its being reared more easily, and less expensively;

* Dictionary of Arts, Manufactures, &c. vol. I., p. 227.

partly by the effect of its down, which enables it better to resist rains and storms.

The wild cochineal, says Berthollet,* when it is bred upon the field nopal, loses in part the tenacity and quantity of its cotton, and acquires a size double of what it has on the wild opuntias. It may, therefore, be hoped that it will be improved by persevering care in the rearing of it, when it will approach more and more to fine cochineal. The fine cochineal, when well dried and well preserved, should have a gray color, bordering on purple. The gray is owing to the powder, which naturally covers it, and of which a little adheres; as also to a waxy fat. The purple shade arises from the color extracted by the water in which they were killed. It is wrinkled with parallel furrows across its back, which are intersected in the middle by a longitudinal one; hence, when viewed by a magnifier, or even a sharp naked eye, especially after being swollen by soaking for a little in water, it is easily distinguished from the factitious, smooth, glistening, black grains of no value, called East India cochineal, with which it is often *shamefully adulterated* by certain merchants. The genuine cochineal has the shape of an egg, bisected through its long axis, or of a tortoise, being rounded like a shield upon the back, flat upon the belly, and without wings. These female insects are gathered off the leaves of the nopal plant, after it has ripened its fruit, a few only being left for brood, and are killed, either by a momentary immersion in boiling water, by drying upon heated plates, or in ovens: the last become of an ash-gray color, constituting the *silver* cochineal, or *jaspeada;* the second are blackish, called *negra*, and are most esteemed, being probably dryest; the first are reddish brown, and reckoned inferior to the other two. The dry cochineal being sifted, the dust, with the imperfect insects and fragments which pass through, are sold under the name of *granillo*.†

* Berthollet on Dyeing, vol. II. p. 147.

† Cochineal keeps for a long time in a dry place. Hellot says that he has tried some 130 years old, which produced the same effect as new cochineal.—Bertholett, vol. II., p. 149.

M. M. Pelletier and Caventon, have investigated the chemical properties of cochineal, in which its coloring matter was skillfully eliminated. Their principal researches were directed to the mestèque cochineal (*coccus cacti*), though a few experiments were also made on some other kinds. The following shows some of the results of their investigation:—

1. Purified sulphuric ether acquired by digestion with it a golden yellow color, amounting, according to Dr. John, to one-tenth of the weight of the insect. This infusion left, on evaporation, a fatty wax of the same color.

2. Cochineal, exhausted by ether, was treated with alcohol at 40°. After thirty digestions in the apparatus of M. Chevreul, the cochineal continued to retain color, although the alcohol had ceased to have any effect on it. The first alcoholic liquors were of a red verging on yellow. On cooling, they let fall a granular matter. By spontaneous evaporation, this matter, of a fine red color, separated, assuming more of the crystaline appearance. These species of crystals dissolved entirely in water, which they tinged of a yellowish-red.

3. Treated with very strong alcohol in the cold, they redissolved, leaving a very animalized brownish matter. The alcoholic solution of these crystals, when thus deprived of its animalized matter, is still susceptible of affording the above crystaline sediment. In this state, although free from animalized matter, especially when they have been redissolved and recovered anew, these crystals, do not however, present the coloring matter pure, as was at first believed.

4. If this matter be treated with sulphuric ether, one portion is dissolved and colors the ether orange-yellow; and it is only after the ether has ceased to have any action on the mass, and when it comes off colorless, that the substance which will not dissolve in the ether may be regarded as the coloring principle, if not absolutely pure, at least very nearly so. The coloring principle of cochineal, insoluble by itself in ether, may, however, be dissolved in small quantity in this liquid through the intervention of the fat crystalizable matter, while the latter becomes less soluble in ether, as it is en-

veloped and protected by a quantity proportionally greater of the coloring principle.

These considerations led M. M. Pelletier and Caventon to make the following experiment, in the hope of stripping the coloring matter of every particle of the fat substance:—

1. They dissolved a certain quantity of their colored crystals in very strong alcohol, and added a quantity of sulphuric ether equal to that of the alcohol employed. The mixture became turbid, but at the end of some days it had grown perfectly clear. It was of a red color inclining considerably to yellow. A good deal of the coloring matter had, however, fallen down on the bottom of the vessel, forming an incrustation of a magnificent purple-red. This matter, treated with ether, no longer yielded any principle; and the properties to be presently detailed lead to the belief, that it may be regarded as the coloring matter of cochineal in a state of purity.

2. By adding new portions of ether to the decanted liquor, a certain quantity of coloring matter may again be thrown down. The alcoholic tinctures in which the first crystals were formed, were evaporated to dryness on the water-bath; and the coloring matter obtained, treated by methods analogous to the preceding, afforded likewise fat crystalizable matter and coloring principle.

Coloring principal of Cochineal.—This matter has a very brilliant purple-red color; it adheres strongly to the sides of the vessels; it has a granular and somewhat crystaline aspect, very different, however, from those compound crystals alluded to above; it is not altered by the air, nor does it sensibly attract moisture. Exposed to the action of heat, it melts at about the fiftieth degree Centigrade (122° Fahr.) At a higher temperature it swells up, and is decomposed with the production of carburetted hydrogen, much oil, and a small quantity of water, very slightly acidulous. No trace of ammonia was found in these products.

The coloring principle of cochineal is very soluble in water. By evaporation, the liquid assumes the appearance of syrup, but never yields crystals. It requires of this matter a portion almost imponderable to give a perceptible tinge of bright pur-

plish red to a large body of water. Alcohol dissolves this coloring substance, but, as we have already stated, the more highly it is rectified, the less of it does it dissolve. Sulphuric ether does not dissolve the coloring principle of cochineal, but weak acids do, possibly owing to their water of dilution. No acid precipitates it in its pure state. This coloring principle, however, appears to be precipitable by all the acids when it is accompanied by the animal matter of the cochineal.

Acids, however, change the color of this substance, converting it into a bright red, then a yellowish-red, and lastly, a yellow. When the acids have not been too concentrated, its proper color may be restored by saturation with alkali. Chlorine changes the color of this principle to yellow, and then destroys it altogether. It produces no precipitate in its solution, unless it contains animal matter. Hence chlorine becomes a useful reagent for trying the purity of this coloring substance. Iodine acts like chlorine, but more slowly. The alkalis, poured into a solution of the coloring principle of cochineal, change its hue to crimson violet. If the alkali be immediately saturated, the original color is restored, and the coloring matter may be recovered without any remarkable alteration in its principal properties. If the action of the alkali has been longer continued, or aided by heat, the violet shade disappears, and the color passes back to red, and then yellow. In this case, the coloring matter is totally altered, for by putting it into contact with those metallic salts which form with it insoluble combinations, we obtain precipitates entirely different from those which the pure coloring matter produces with the same salts.

Lime water produces a violet precipitate with the coloring matter of cochineal. Barytes and strontites do not occasion any precipitate in a solution of the coloring matter; but they change the hue to violet, like alkalis. The affinity of alumina for the coloring matter is very remarkable. When that earth, newly precipitated, is put into a watery solution of the coloring principle, this is immediately seized by the alumina. The water becomes colorless, and a fine red lake is obtained, if we operate at the temperature of the atmosphere; but if the

liquor has been hot, the color passes to crimson, and the shade becomes more and more violet, according to the elevation of the temperature, and the continuance of the ebullition.

If, before adding alumina to the watery solution of the coloring principle, some drops of an acid be poured into this, the lake obtained is at first of a brilliant red; but the slightest heat changes it to a violet hue. The same effect is produced by putting into the solution of the coloring principle some grains of an aluminous salt. But, on the contrary, if we add to the coloring principle a small quantity of alkali, potash, soda, ammonia, or their subcarbonates, and if we then diffuse through the solution some gelatinous alumina, the liquor rendered violet by the alkalies returns instantly to the red, by the formation of a lake which readily precipitates. In this case, we may keep the mixture boiling for a long time, without making the lake perceptibly violet. This property cannot, however, be quite restored by alkaline saturation, especially if the action of the alkali has been some time continued. These facts may serve to explain several phenomena which have been observed in the operations of the scarlet or crimson dye.

Most salts exercise on the coloring matter of cochineal an action characterized by changes in the hue; but only a small number are capable of precipitating it, when it is in a state of perfect purity.

Nitrate of silver has no action on it. The soluble neutral salts of lead change the red coloring matter to violet; and the acetate of lead determines immediately an abundant precipitate. This precipitate keeps its tint, though there be an excess of acetic acid. By passing a stream of sulphuretted hydrogen gas through the combination, it is decomposed, and the coloring matter is then obtained in a state of purity. Protonitrate of mercury produces a violet precipitate in the solution of the coloring matter; the deutonitrate precipitates less easily the coloring matter; what falls is of a scarlet hue. Corrosive sublimate has no action on it. The salts of copper cause no precipitate, but change the color to violet; and the salts of iron give a brownish tint, without producing any precipitate.

Chlorine precipitates the animal matter of cochineal, but iodine produces no sensible effect on its solution. Potash and soda communicate to water the power of dissolving this animal matter in abundance. When they are neutralized by acid, the matter is recovered; but if the acid is in excess, it forms an insoluble compound with an animal matter. All the salts with excess of acid precipitate the animal matter, and are brought to the neutral state.

The salts of tin exercise upon the coloring matter of cochineal a remarkable action. The muriatic protoxide of tin forms a very abundant violet precipitate in the liquid. This precipitate verges on crimson, if the salt contains an excess of acid. The muriatic deutoxide of tin produces no precipitate, but changes the color to scarlet-red. If gelatinous alumina be now added, we obtain a fine red precipitate, which does not pass to crimson by boiling. To this coloring principle the name *carminium* has been given, because it forms the basis of the pigment called carmine.—(See *Carmine.*)

By incinerating cochineal, certain salts were found in the residue. Hence the general products are as follows:—

1. Carminium. 2. A peculiar animal matter. 3. A fat matter, containing stearine, elaïne, and odorant principle. 4. Salts, phosphate of lime, carbonate of lime, muriate of potash, phosphate of potash, potash united to an organic acid.

The specific gravity of genuine cochineal is 1·25; that of the cochineal loaded with the barytic sulphate 1·35. It was taken in oil of turpentine and reduced to water as unity, because the waxy fat of the insects prevents the intimate contact of the latter liquid with them, and the ready expulsion of air from their wrinkled surface. They are not at all acted upon by the oil, but are rapidly altered by water, especially when they have been gummed and barytified.

CUDBEAR was first made an article of trade, in Great Britain, by Dr. Cuthbert Gordon, from whom it derived its name, and was originally manufactured on a great scale by Mr. G. Mackintosh, at Glasgow, over 65 years ago. Cudbear or persio is a powder of a violet red color, difficult to moisten with water, and of a peculiar but not disagreeable odor. It is

partially soluble in boiling water, becomes red with acids, and violet blue with alkalis. It is prepared in the same way as archil, only towards the end the substance is dried in the air, and is then ground to a fine powder, taking care to avoid decomposition, which renders it glutinous. In Scotland they use the lichen tartareus, more rarely the lichen calcareus, and omphalodes; most of which lichens are imported from Sweden and Norway, under the name of rock moss. The lichen is suffered to ferment for a month, and is then stirred about to allow any stones which may be present to fall to the bottom. The red mass is next poured into a flat vessel, and left to evaporate till its urinous smell has disappeared, and till it has assumed an agreeable color verging upon violet. It is then ground to fine powder. During the fermentation of the lichen, t is watered with stale urine, or with an equivalent ammoniacal liquor of any kind, as in making archil.—(See *Archil.*)

F.

FUSTIC, is a wood of the Morus tinctoria. It is light, not hard, and pale yellow with orange veins; it contains two coloring matters, one resinous, and another soluble in water. The latter resembles weld, but it has more of an orange cast, and is not so lively. Fustic is a very valuable dye-wood for the production of greens on wool and woolen goods. It is also much used in the production of yellows.* A strong decoction of this wood has a deep yellow-red color; when diluted with water, it becomes orange-yellow. The acids make this liquid turbid, with some inconsiderable differences; a slight greenish-yellow precipitate falls, and the supernatant liquid is of a pale yellow. The alkalies redissolve the precipitate, and give the liquor a deep reddish color. The following experiments show the action of the re-agents on the coloring substance of this wood:—

1. Alkalies render the color deeper and almost red.

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* See Parts III. and IV.

2. Alum forms a small quantity of yellow precipitate; the liquor remains transparent, and of a less deep yellow.

3. Alum and tartar together, afford a precipitate which has the same color, but it is slower in falling. The liquor retains a still deeper hue.

4. The muriate of soda makes the color a little deeper, without occasioning turbidity.

5. Sulphate of iron forms a precipitate at first yellow, but which grows more and more brown; the liquor continues brown, and without transparency.

6. Sulphate of copper affords an abundant precipitate of a brown-yellow; the supernatant liquor retains a feeble greenish color.

7. Sulphate of zinc yields a greenish-brown precipitate; the liquor retains a reddish-yellow color.

8. Acetate of lead forms an abundant orange-yellow precipitate; the liquor is transparent, and of a very faint greenish-yellow.

9. The solution of tin gives a very copious precipitate of a fine yellow, a little brighter than the preceding; the liquor retains a faint yellow color.

Chaptal recommends to boil in the yellow decoction of fustic, parings of skins, glue, or other animal matters; and then, without filtering, the stuff is to be worked in it, which will thus take the most beautiful and intense color.* For the best methods of dyeing yellow, see chapter IV, Part III; see also chapter II., Part IV., and chapter I., Part III., article *Tin;* see also *Calico-Printing*.

G.

GARANCINE.—(See *Madder*.)

H.

HEMATINE is the name given by its discoverer Chevreul to a crystaline substance, of a pale pink color, and brilliant

* Mém. de l' Institut, tom. I.

lustre when viewed in a lens, which he extracted from log-wood, the *hæmatoxylon Campechianum* of botanists. It is, in fact, the characteristic principle of this dyewood. To procure hematine, digest during a few hours ground log-wood in water heated to a temperature of about 130° F.; filter the liquor, evaporate it to dryness by a steam bath, and put the extract in alcohol of 0·835 for a day. Then filter anew, and after having inspissated the alcoholic solution by evaporation, pour into it a little water, evaporate gently again, and then let rest in a cool place. In this way a considerable quantity of crystal of hematine will be obtained, which may be readily purified by washing with alcohol and drying. M. Chevreul, in a series of experiments obtained the following results:—

1. When subjected to any distillation in a retort, hematine affords all the usual products of vegetable bodies, along with a little ammonia; which proves the presence of azote.

2. Boiling water dissolves it abundantly, and assumes an orange-red color, which passes into yellow by cooling, but becomes red again with heat.

3. Sulphurous acid destroys the color of solution of hematine.

4. Potash and ammonia convert into a dark purple-red tint, the pale solution of hematine; when these alkalies are added in large quantity, they make the color violet blue, then brown-red, and lastly brown-yellow. By this time, the hematine has become decomposed, and cannot be restored to its pristine state by neutralizing the alkalies with acids.

5. The waters of baryta, strontia, and lime, exercise an analogous power of decomposition; but they eventually precipitate the changed coloring matter.

6. A red solution of hematine subjected to a current of sulphuretted hydrogen becomes yellow; but it resumes its original hue when the sulphuretted hydrogen is removed by a little potash.

7. The protoxide of lead, the protoxide of tin, the hydrate of peroxide of iron, the hydrate of oxides of copper and nickel, oxide of bismuth, combine with hematine, and color it blue with more or less of a violet cast.

Hematine precipitates glue from its solution in reddish flocks. This substance has not hitherto been employed in its pure state; but as it constitutes the active principle of logwood, it enters as an ingredient into all the colors made with that dye-stuff. These colors are principally violet and black. Chevreul has proposed hematine as an excellent test of acidity.*—(See *Logwood.*)

I.

INDIGO.—In chapter II. we mentioned that, besides the green of leaves and the colors of flowers, which we considered common to all vegetables, there were other coloring matters which existed only in certain kinds of vegetables, and in particular parts of the vegetable. Indigo is one of these: it belongs to a genus of loguminous plants found in India, Africa, and America, named *Indigofera.* Botanists have described about sixty species of this genus. These all yield indigo; but the species from which it is usually extracted are the *I. anil*, the *I. argentea*, and the *I. tinctoria.* It is also extracted from a tree very common in Hindostan, (the *Nerium tinctorium* of botanists,) and from the woad plant (Isatis tinctoria), which is a native of Great Britain, and of other parts of Europe. The coloring matter of these plants resides wholly in the cellular tissue of the leaves, as a secretion or juice; not, however, in the blue state in which we are accustomed to see indigo, but as a white substance, which, as we shall presently see, remains white so long as the tissue of the leaf remains perfect.† When

* *Annales de Chimie*, lxxxi. p. 128.

† A *blue* color, serviceable for dyeing, may be extracted from buckwheat, in the following manner:—The stalks are cut before the grain has become mature; they are spread out upon the earth and exposed to the sun; and suffered to remain till the grain separates with facility. When this has been effected, the straw is collected, wetted, and allowed to ferment until decomposition take place, and the heap has assumed a blue appearance. It is then formed into balls or cakes, and dried by the sun, or in a stove. These masses being boiled in water will impregnate it with a deep blue, which neither vinegar nor sulphuric acid will discharge. Alkalis will change it to a red; the powder of nut-galls reduce it to a perfect black;

this tissue is by any means destroyed, the indigo absorbs oxygen from the atmosphere, and becomes blue.

Of the early history of indigo little is known, neither is it known when it was first used as a dye-stuff. The Greeks and Romans used it as a paint, under the name of Indicum. Its value, as a dye-stuff, was not known in Europe till nearly the close of the sixteenth century, when it was imported from India by the Dutch; but English legislators, for a long time, prohibited its use in Great Britain under severe penalties. These prohibitions continued in force till the reign of Charles II., and the reason consisted in its being considered a corrosive substance, and capable of destroying the fibres of cloth, and therefore calculated to injure the character of the dyers. This opinion, no doubt, sprung from the strong and interested opposition given to its use by the cultivators of the woad, which was then regarded as an important branch of national industry.*

The plant which yields the indigo in Bengal is a small straight plant, furnished with thin branches, which spreads out and forms a sort of tuft; the average height is four feet, but on good ground it sometimes attains a height of even seven feet. The leaves are soft, and somewhat like those of the common clover, and the blossoms are of a light reddish

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and, by evaporation, it will become a beautiful green. Stuffs dyed with this preparation, and by the usual method, take the dyes from other vegetable substances; the blue is very beautiful, and the color stands well.

* When Indigo was first introduced, only a small quantity was added to the woad, by which the latter was much improved; more was afterwards gradually used, and, at last, the quantity became so large, that the small admixture of woad served only to revive the fermentation of the indigo. Germany thus lost a production by which farmers, merchants, carriers, and others, acquired great riches. In consequence of the sales of woad being so much injured, a prohibition was issued against the use of indigo by Saxony, in the year 1650. In the year 1652, Duke Ernest, the Pious, caused a proposal to be made to the diet by his envoy, *that indigo should be entirely banished from the empire*, and that an exclusive privilege should be granted to those who dyed with woad. This was followed by an imperial prohibition of indigo on the 21st of April, 1654, which was enforced with the greatest severity in his dominions. The same was done in France; but in the well-known edict of 1669, in which Colbert separated the superior from the inferior dyers, it was stated, that indigo should be used without woad; and in 1737, dyers were left at liberty to use indigo alone, or to employ a mixture of indigo and woad.

color. The plant is at its highest perfection when in full blossom, and yields the greatest quantity of indigo.

There are two methods for extracting the coloring matter from the leaves: the first is by fermentation and beating. This process is conducted in two large brick cisterns or vats, built in relation to one another, like two steps of a stair. The upper one is termed the steeper, because in it the fermentation is conducted. At the bottom of this cistern there is a plug-hole entering into the other, through which, when the process of fermentation is finished, the fluid is run off into the lower cistern, denominated the beater, because in it the process of beating the fluid by paddles, to separate the feculæ from the water, is performed. The plant, when cut, is tied up in bundles about five feet in circumference, and conveyed as quickly as possible to the vat; for, were it kept but a short time in heaps, the indigo in the plant would be destroyed. The upper vat is filled to about five or six inches from the top with these bundles laid in regular tiers. To prevent the throwing up of the herb by the swelling and agitation caused by the fermentation, there are irons built in the two side walls, opposite to one another, to which are fastened beams of wood, which traverse the whole length and breadth of the vats. When the vat is sufficiently filled with the vegetable, a strong grating of bamboo, large enough to cover the whole surface, is laid over the plant, and fastened down by the cross beams. These precautions being completed, cold water is poured as quickly as possible into the vat, till the surface rises within three or four inches of the upper edges. In a short time fermentation commences, and is completed in from nine to twelve hours. Towards the end, the action is very brisk, swelling and throwing up frothy bubbles, which sometimes rise like pyramids. These bubbles are white at first, but after a little exposure to the air, they become blue, and then purple. This part of the operation requires great skill. If the fermentation be too long, the indigo will be much damaged; and, if too short, the quantity is much diminished. When the liquor ceases to swell, it is let out into the second or beating vat, and is then of a light green color.

The liquor being now into the lower or beating vat, a number of men enter it, furnished with oar-shaped paddles, about four feet in length; they continue to walk backwards and forwards, agitating or beating the liquor with these paddles. At the commencement of this agitation the liquor begins to froth; but this is prevented, provided the fermentation has not gone on too long, by a few drops of oil. In the course of an hour and a half, the liquor begins to granulate, and assume the appearance of agitated water, full of wood grounds. This part of the process also requires considerable care and management; for, if the beating be stopped too soon, the indigo will not be all separated from the liquor, occasioning considerable loss; if continued too long, the granulated particles are broken, and dispersed through the liquor, and do not readily fall to the bottom. When the beating is completed, the vat is allowed to settle; the grains which constitute the indigo fall to the bottom, and the supernatant liquor is let off by plug-holes in the side of the vat. The precipitate is then removed to a copper-boiler, to which there is a fire kept till the liquor becomes as thick as oil. Some manufacturers bring it to this state by causing the liquor to boil; others by keeping it at a moderate temperature. The former process produces lighter indigo than the latter. In this state it is put into a large flat vessel, furnished at the one end with a cloth filter. After the most of the liquor has filtered through, the indigo remains in the vessel about the consistence of butter. It is then put on proper frames, and subjected to considerable pressure by a sort of screw press; and is now ready to be cut into small cakes, which are placed upon boards in a drying-stove; when dry, these cakes are packed up, and in this state form the indigo of commerce.

The other method of extracting the indigo from the plant differs from that described, only in the first operations. Instead of putting the plant into the vat when newly cut, it is spread out to dry in the sun for two days, and then thrashed to separate the leaves from the stems. The leaves are then kept until they have changed from a green to a bluish-gray, or lavender color; they are then put into the first vat with

warm water, and kept stirring, till the leaves are so completely wetted as to sink. The liquor is then instantly let off into the beating-vat, where it is treated as already described.

The chemical changes which take place during these operations are not well understood, and the various opinions expressed by chemists concerning them are not very easily reconciled. Berthollet in his Elements of Dyeing, while describing the process of the first or fermenting vat, says, "In the first a fermentation is excited, in which the action of the atmospheric air does not intervene, since an inflammable gas is evolved. There probably results from it some change in the composition of the coloring particles themselves, but especially the separation or destruction of a yellowish substance, which gave to the indigo a greenish tint, and rendered it susceptible of suffering the chemical action of other substances. This species of fermentation passes into a destructive putrefaction, because the indigo, as we shall see, has a composition analogous to that of animal substances."

Dr. Ure, in his Dictionary of Arts and Manufactures, says, that from some experiments made upon the gases given off during fermentation, they were found to be composed, when taken about the middle of the operation, of 27·5 of carbonic acid gas, 5·8 of oxygen, and 66·7 of nitrogen, in the 100 parts; and towards the end of the operation, they consisted of 40·5 of carbonic acid gas, 4·5 of oxygen, and 55 of nitrogen. No carburetted hydrogen is disengaged. "The fermenting leaves," using the Doctor's words, "apparently convert the oxygen of the air into carbonic acid, and leave its nitrogen free." They also evolve a quantity of carbonic acid spontaneously. It will be observed that these two opinions *are decidedly contradictory;* the one says that the action of the atmosphere does not intervene, and that an inflammable gas is evolved: the other, that there is no inflammable gas evolved, and that the air is apparently the principal agent in effecting the various changes. But when we recollect that the leaves are all under the liquor, and kept so by the fixed position of the beams, there can be little contact between the fer-

menting leaves and the air; hence the conversion of its oxygen into carbonic acid gas must be very limited.

Dr. Kane says of this process:—"After some time a kind of mucous fermentation sets in; carbonic acid, ammonia, and hydrogen gases are evolved, and a yellow liquor is obtained, which holds the indigo dissolved. The theory of this action is, that by the putrefaction of the vegeto-animal matter of the leaves, the indigo is kept in the same white soluble condition in which it exists in the plant."

Dr. Thomson, in his Vegetable Chemistry, supposes that the indigo exists in the plant in union with another substance, and during fermentation that substance is decomposed, and carbonic acid gas consequently evolved. But we will give his own words. "The leaves of the indigofera yield a green infusion to hot water, and a green powder may be precipitated from it; but unless a fermentation has taken place, neither the color nor the properties have any resemblance to those of indigo. There is little doubt that in the leaves it exists in the state of *white* or *deoxygenated indigo*, and that during the fermentation, it combines with the requisite quantity of oxygen to convert it into *blue indigo*. The evolution of carbonic acid gas, renders it not unlikely, that the *white indigo* was in combination with some principle (probably of an alkaline nature) which was decomposed during the fermentation."

These discrepancies of opinion, relative to the nature of the changes which take place during fermentation, show that proper investigations have not yet been made into this part of the process; and it is obvious that until this be done, any hypothesis founded upon statements concerning the gases evolved, must be unsatisfactory. The supposition hazarded by Dr. Thomson *certainly appears to us the most consistent;* for, as deoxidized indigo combines readily with alkaline substances, and as the vegetable alkalies almost always contain nitrogen, we can easily conceive of that gas being evolved either free or in combination with hydrogen, forming ammonia. It may yet be found that indigo, like gallic acid (noticed in chapter II., Part III.), does not exist in the living vegetable,

but is the result of a decomposition of some more complicated compound.

The chemical action which takes place in the second vat in which the beating process is conducted, is apparently much more easily explained, and therefore the discrepancies among writers on the subject are not so great. We shall give only two quotations. Berthollet says, "Hitherto the coloring particles have preserved their liquidity. In the second operation the action of the air is brought into play, which, by combining with the coloring particles, deprives them of their solubility, and gives them the blue color. The beating serves at the same time to dissipate the carbonic acid formed in the first operation, whose action is an obstacle to the combination of the oxygen." Dr. Ure's opinion is thus expressed:—"The object of the beating is threefold; first it tends to disengage a great quantity of carbonic acid present in the fermented liquor; secondly, to give the newly-developed indigo its requisite dose of oxygen, by the most extensive exposure of its particles to the atmosphere; and thirdly, to agglomerate the indigo in distinct flocks or granulations. In order to hasten the precipitation, lime water is occasionally added to the fermented liquor in the progress of beating; but it is not indispensable, and has been supposed to be capable of deteriorating the indigo."

That the liquor in the beating vat absorbs oxygen from the air, as the indigo separates from it, has, we believe, been ascertained by direct experiment; and it is also known to manufacturers, that sunshine assists in the separation of the indigo from the liquor. But, though these facts may have been ascertained, it does not give us any positive information respecting the nature of the change which takes place in the vat; neither can we expect such information till it be ascertained what keeps the indigo in solution previous to the operation of beating. Both oxygenized and deoxygenized indigo are insoluble in water; there must therefore be some substance in the liquor capable of holding the indigo in solution previous to being beat. According to our present knowledge of the nature of white or deoxydized indigo, there is no other substance

can hold it in solution except the *alkalies* and *alkaline earths*. But during such a generation and emission of carbonic acid gas, the existence of any alkali capable of holding the indigo in solution in those vats *is next to impossible*, and the results prove the contrary; for while the acid is liberated, the indigo becomes more insoluble—a result which is just the opposite of what we conceive would take place were an alkali present; except we suppose that the carbonic acid is the result of the decomposition of the alkali, or is evolved, as already hinted, from the decomposition of a substance which is resolving itself into indigo.

Having given the opinions of several chemists upon the chemical nature of the manufacture of indigo, and hinted at the difficulties which some of these theories involve, we shall now consider the nature of indigo; and, whatever be the chemical changes which take place in the beating operation, we are certain *that the indigo is precipitated in union with various other substances, rendering it very impure.* The best indigo of commerce, according to several analysis, contains only 75 per cent. of pure indigo, while some of the inferior kinds do not contain above 29 or 30 per cent. Part of these impurities may be dissolved in water, by alcohol, by dilute acids, and by alkaline leys. Berzelius found these impurities to consist, besides a little iron, clay, lime, magnesia and silica, of a substance resembling vegetable gluten,* which may be obtained by digesting indigo in dilute sulphuric acid (vitriol); also a *brown matter* which he terms indigo brown, and which he obtained by digesting the indigo in strong potash ley after the gluten was extracted. He found also a red resinous substance, which he termed indigo red, and was obtained by boiling the indigo in alcohol, after digestion in the acid and alkali. Several experiments have been made upon the coloring properties of these substances, but the results have shown that they are incapable of being used as a dye. On the contrary, as we shall afterwards have occasion to remark, some

* Gluten is the substance which gives wheat flour, starch, &c., the property of paste. It is a distinct vegetable substance composed of oxygen, hydrogen, nitrogen, and carbon, and it is the most nutritive of all vegetable compounds.

of them being more soluble than the pure indigo, and much more easily decomposed, their presence is very hurtful in some cases where particular attention is not paid to those properties, especially when the indigo is to be used as sulphate of indigo.

From the great difference in the quality of indigo, it would be of the utmost importance to the dyer to have an easy method of ascertaining its true value. *This has not yet been obtained;* the various methods proposed generally imply formal analysis, which, however important they may be to the dyer, *are too delicate and tedious to be generally adopted.* The method universally practised in the dye-house is, comparison—putting several samples together, breaking and comparing their clean surfaces. The best indigo generally is of the deepest violet blue, and the finest grain, if scratched by the nail, presents a copper hue; but notwithstanding great care and long practice in thus judging of the value of indigo, it often happens that the lot chosen turns out to be of inferior quality, and is not known until it is in the vats, and its price marked against the dyer.*

The process of Berzelius, just alluded to, is to take a weighed quantity of the indigo of commerce in very fine powder, and digesting it in dilute sulphuric acid, next filter and wash it; then digest what remains on the filter in strong potash or ammonia, filter and wash again; then boil the remainder in strong alcohol; what remains is pure indigo, and by weighing it, we find the per centage of real indigo in the sample.

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* Fritsche of St. Petersburgh has communicated to M. Chevreul (L'Institut. 460,) a method—an improvement upon that of Liebig—of separating indigotine, which he considers will serve for testing the value of commercial indigo. He takes 1 part of commercial indigo, and 1 part of grape sugar, and places them in a flask capable of containing 40 parts of liquid. He fills half the flask with hot alcohol, and then adds 1½ parts of strong liquid caustic soda to another equal portion of alcohol, and fills up the flask with them. The flask thus filled is allowed to remain at rest till it becomes clear. The fluid is then withdrawn, by means of a syphon, into another flask. This liquid is first yellow, but, by exposure to the air, it changes to red, violet, and blue, depositing microscopical crystals, which are larger in proportion to the gradual admission of the oxygen of the air, and consist of pure indigo. They are then thrown on a filter, and washed rapidly with hot water, in order to remove a substance produced by the action of the soda on the sugar, which is insoluble in alcohol, but soluble in hot water. From 4 ounces of inferior indigo of commerce, he obtained, by the first infusion, 2 ounces of pure indigo blue: a second infusion of the residue gave only a drachm of indigo.

Another process, somewhat similar, was recommended by M. Chevreul. He treated the powdered indigo first with water, then with alcohol, and afterwards with muriatic acid. The following is the result of his experiment, taking a hundred parts :—

1. Treated with water,	A green matter united to ammonia,	12 parts.
	A little deoxydized indigo,	
	Extractive,	
	Gum,	
2. Treated with alcohol,	Green matter,	30 —
	Red resin,	
	A little indigo,	
3. Treated with muriatic acid,	Red resin,	6 —
	Carbonate of lime,	2 —
	Red oxide of iron,	2 —
	Alumina,	3 —
4. There remained,	Silica,	3 —
	Pure indigo,	45 —
		100 —

Although these processes give a much nearer and more certain approximation to the true value of indigo than the mere comparison of samples by the eye, still they are not direct enough, and require too much nice management to be resorted to generally in the dye-house. Those, indeed, who are most affected by a bad bargain, and ought to be most interested in any process that would enable them to avoid loss, and who have the requisite time and means to try such experiments, do not seem impressed with their importance. Neither are they always possessed of the requisite dexterity of manipulation; and moreover, in general, seem unwilling to devote half a day to ascertain what they suppose can be accomplished, at least approximately, in an hour's time by comparison.

The following method has been discovered by Dr. Dana, of Lowell, Mass., for ascertaining the real value of commercial indigo :—

The grains of indigo are to be reduced to a fine powder, and put into a small glass flask, with two and a half ounces, by measure, of a solution of carbonate of soda, of from 30° to 35° of strength by Twaddle's hydrometer; after boiling for a few minutes, 8 grains of crystals of chloride of tin (crystalized red spirits,) are to be added, and the whole boiled for half an hour. By this means the indigo is dissolved, and the liquor appears of a yellow color. 6 grains of bichromate of potash (red chrome,) is dissolved in 6 ounces of water; and, when the flask is withdrawn

from the lamp, this solution of chrome is added, which precipitates the indigo blue, along with a trace of the indigo red, leaving the other ingredients in solution. The whole is next to be poured upon a double weighed filter, and the precipitate washed with 1 oz. of muriatic acid diluted with 3 oz. of boiling water, and afterwards with hot water, till nothing but water returns. Then separate, dry, and weigh the filters, and make a note of the weight of the precipitate; burn one filter paper against the other, and their difference in weight is the quantity of silica contained in the indigo. This, deducted from the weight of the precipitate, gives the quantity of pure indigo.

Mr. Walter Crum, who communicated the above to the British Association in 1841, added, that carbonate of soda, with protoxide of tin, dissolves indigo, and forms a yellow solution, but so slowly that he doubts if all the 10 grains are acted upon. He thinks Dr. Dana must mean soda-ash, which contains a notable quantity of caustic soda, but a much weaker solution of caustic soda would answer the purpose.

Pure indigo, besides its great value as a dye-drug, possesses some of the most important and interesting chemical properties, which are as yet not very well understood. Some of these we shall notice before entering upon its practical value. If pure indigo be heated to about 550° Fah. it sublimes, producing a beautiful transparent vapor of a reddish-violet color, which adheres to the sides of the vessel in which it is sublimed, or on the top of the cinder which is left in long needle-shaped crystals. Mr. Crum, whose investigations have thrown great light upon the chemical nature and properties of indigo, employed for its sublimation the covers of two platinum crucibles, about three inches diameter, and of such a form that, when placed with their concave sides inward, they were about three-eighths of an inch distant in the middle. About the centre of the lower lid were placed thinly, about ten grains of indigo, precipitated from the dyers' vat, in small lumps about a grain each; then, having put on the cover, the flame of a spirit-lamp was applied beneath the cover containing the indigo. The indigo immediately began to melt with a hissing noise, which, when it had nearly ceased, the lamp was withdrawn, and the whole allowed to cool. On removing the cover, the sublimed indigo was found planted on its inner surface, and a little remained upon the charred matter, and was

easily removed. In this way he obtained from 18 to 20 per cent. of the indigo employed.*

As few working men have access to platinum crucible covers to repeat this experiment, we state, that it may be successfully repeated by taking a thin porcelain plate, or a sheet of iron or copper, with the indigo placed upon it, and covering it with a pretty large watch-glass; when the plate under the indigo is heated by a lamp, the vapors very soon make their appearance; and, towards the close, the glass appears black, owing to the coating of indigo which adheres to its inner surface. To obtain pure indigo for this experiment, the easiest method is to take a little of the yellow solution of the indigo vat. Adding to this a few drops of muriatic acid, to dissolve the salts of lime, the blue indigo falls to the bottom, and may readily be collected upon a filter, then washed and dried. A very pretty and easy method has been described by T. Taylor, Esq., which is as follows:—

Any quantity of indigo is to be reduced to powder, and mixed with about half its weight of plaster of Paris. To these materials so much water is to be added, as will bring the whole to a thin paste. This is to be spread evenly upon an iron plate to the depth of the eighth of an inch, and allowed to remain exposed to the air, or to a gentle heat, until it is tolerably dry. If the heat of a large spirit-lamp be now applied to the under surface of the plate, the indigo begins to smoke, emits a disgusting odor, and in a few minutes is covered over with a dense purple-red vapor, which condenses into brilliant flattened prisms, or plates of an intense copper-color, forming a thick velvety coating over the surface immediately exposed to heat. When this ceases to appear, the heat is of course to be withdrawn; and when cold, the sublimed crystals may be readily lifted or swept off, without in the slightest disturbing the subjacent mass. The operation is exceedingly beautiful to look at, is effected in a few minutes, and any quantity of materials might be acted upon. For ultimate analysis, the sublimed indigo must be previously washed with alcohol or ether. The object of the plaster is to prevent the indigo from cracking during drying.†

Pure indigo, whether obtained by sublimation, or other chemical means, is of a deep blue, approaching to violet. If scratched or rubbed, it has a strong copper hue, and a metallic lustre. It has neither taste nor smell, and is remarkable for its neutral properties. It is insoluble in water, alcohol,

* Annals of Philosophy. † Chemical Gazette.

ether,* alkalis, and dilute acids. Its chemical composition is 6 atoms carbon, 5 hydrogen, 1 nitrogen, and 2 oxygen.

If indigo be thrown into fused hydrate of potash, its blue color disappears: it dissolves, and is partly decomposed along with the water of the alkaline hydrate; hydrogen, and ammoniacal gases are evolved, while carbonic acid, and another acid named valerianic acid, having properties similar to acetic acid, are formed, and combine with the potash. By digesting this mixture with a little sulphuric acid, the alkali combines with it, and the new acid crystalizes. This acid, combined with alkalis, and other bases, forms a very interesting series of salts.

If indigo, in fine powder, be added to nitric acid, diluted with seven or eight times its weight of water, and a gentle heat be applied, it dissolves with effervescence, forming a yellow liquid. After standing a little, this liquid may be decanted from any resinous matter found during the process, and con-

* M. Vogel, a French chemist, remarks that when the vapor of ether is passed into a solution of indigo in sulphuric acid largely diluted with water, it becomes decolorated. This effect, he says, is produced more readily when the ether is heated to ebullition in a matrass furnished with a bent tube, which is immersed in the solution of indigo, and if the matrass be suddenly cooled, so that the solution of indigo rises in the tube, and passes into the matrass by the pressure of the air. When he attempted, on another occasion, to decolorate indigo by means of ether which had been rectified over potash, he could not so readily effect it, which induced him to believe that the impure ether, which contained sweet oil of wine, or probably aldehyd, was more fit for the decoloration of indigo than pure ether. To satisfy himself, he added to a solution of indigo in a bottle a few drops of aldehyd, and he observed that the liquor—at first of an emerald green color—became of a pale green, and after some days became of a yellowish brown. As to the aldehyd which he employed, it contained alcohol, not having been rectified; he afterwards made use of pure aldehyd, which was separated from its crystaline combination by ammonia: a few drops of this pure aldehyd were sufficient to destroy the blue color of indigo in a very short time, the solution becoming of a straw yellow. When the aldehyd was evaporated by heat, the blue color could not be made to reappear. The addition of potash, and of red oxide of mercury, were not capable of restoring the blue color. On evaporating the decolorated liquor there remained a brown substance analogous to ulmin. This decoloration of indigo by aldehyd occurs only when the indigo is dissolved in sulphuric acid. Indigo in fine powder, diffused through water, undergoes no change by aldehyd: neither the tincture of litmus, nor the spirituous tinctures of cochineal or turmeric, are decolorated by aldehyd.

centrated by evaporation; and speedily there will be found deposited a quantity of yellowish-white crystals, having a sourish-bitter taste, and requiring about 100 parts of cold water for their solution. This was formerly termed indigotic acid, but is now called anilic acid, from the species and name of one of the plants which yield indigo. It combines with all known bases, forming salts, which have generally a yellow color. It gives a blood-red color to solutions of the persalts of iron.

If indigo be added to strong nitric acid, and heat be applied, it quickly dissolves, evolving a great quantity of nitrous gas. On allowing the liquid to cool, a large quantity of semitransparent yellow crystals are formed, having a very bitter taste. This is what was, till lately, called carbazotic acid; but this name has been changed to picric acid.

To obtain it in a purer state, the crystals obtained by the above operation are to be washed in cold water, and then boiled in water sufficient to dissolve them; next filtering the liquid and allowing it to cool. The acid again crystalizes in yellow brilliant prisms. This acid may also be obtained by the action of nitric acid upon anilic acid.

Picric acid is very permanent in its constitution. When fused in chlorine or with iodine, it is not decomposed, nor does a solution of chlorine affect it. Cold sulphuric acid has no action upon it, but dissolves it when hot. Boiling hydrochloric acid does not act upon it, but nitro-muriatic acid (aqua regia) dissolves it with difficulty. It acts like a strong acid upon metallic oxides, dissolving them, and forming peculiar crystalizable salts. Its salts are yellow; they detonate strongly when sharply heated, and sometimes by a blow, particularly the potash salt. When a little of it is gradually heated in a glass tube, it first fuses, and then suddenly explodes, breaking the tube to pieces. Care is necessary in making this experiment, as the fragments of glass may injure the face.

This acid is an excellent test for the presence of potash in any fluid. A solution of it in alcohol produces a bright yellow crystaline precipitate, even in a diluted solution of the

alkali. It is thus more sensible than the chloride of platinum, commonly employed for the detection of potash; for that reagent does not produce a precipitate in dilute solutions of that alkali.

When indigo is acted upon by very diluted fuming nitric acid, it unites with two atoms more of oxygen, and is consequently converted into a new substance, which has received the name of *isatine*. This substance under the influence of alkalis, absorbs one equivalent more of water, and assumes an acid character, and is termed *isatinic acid*. This acid combines with other substances, forming a series of compounds, the nature of which is not yet very well known. Chromic acid has a similar action upon indigo as nitric acid.

When indigo in the dry state is brought into contact with dry chlorine, no chemical action is observed; but when indigo suspended in water is subjected to the action of chlorine, several new products are formed. When the fluid thus acted upon is distilled, a fluid product in minute quantity passes over with the distilled water, and collects under it in the receiver, in the form of white scales which has been termed *chlorindoptin*. It is sparingly soluble in water, but copiously in alcohol. The substance which remains in the retort is found to be a mixture of several new products. On being dissolved in boiling alcohol, it yields on cooling, red prismatic crystals of a bitter taste, and very insoluble in water; this has been named *chlorisatin*. It dissolves in a solution of caustic potash, producing a red color. The salts of lead give with this solution a yellow precipitate, which becomes a fine scarlet by standing. The salts of copper, (bluestone, &c.,) give a brown, which becomes blood-red by exposure to the air.

In the alcoholic solution another substance is found, having an equivalent more of chlorine than that named above; this is termed *bichlorisatin*. Its properties, however, are analogous to those of chlorisatin; its solution in potash gives a yellow precipitate with the salts of lead, but does not alter by exposure to the air; and with the copper salts it gives a yellowish brown, which passes to blood red.

When chlorine is passed through a solution of chlorisatin, another substance named *chloronile* is formed. This crystalizes in scales of a brass yellow color, and, when dissolved by potash, gives a beautiful purple color.

If indigo in powder be added to a solution of caustic potash, of specific gravity 1·35; (7 Twaddell,) and boiled, an orange yellow salt is formed. The solution of the boiled mass becomes blue in the air from absorption of oxygen, like a solution of white indigo, and blue indigo precipitates.

Besides the compounds resulting from the action of nitric acid and chlorine upon indigo, there are several others which from their true characters being still little known, we have not thought it necessary to enumerate. Some practical dyer may indeed be inclined to ask, *what those already noticed have to do with dyeing?* We are sorry that with respect to some of them, we cannot give any satisfactory answer to the question; but the same question was asked, when chemists first intimated that chromic acid produced yellow salts when combined with lead; yet this simple hint has completely revolutionized various departments of dyeing, as we shall have occasion to notice when we come to treat of the mineral coloring matters in next chapter; and the action of chromic acid upon indigo, as already observed, has been both a source of annoyance and advantage to the dyer. Previous to the use of alkaline substances with the salts of lead, dyers seldom could get an evenly *chrome* green; the chromic acid being set at liberty acted upon the indigo which was upon the yarn, destroying in part the blue color, after which the green was all light yellow blotches. These annoyances are still felt where the new process of working the lead solution with an alkali is not practised. But this same action of chromic acid upon indigo has been taken advantage of by calico printers, when they want a white pattern on a blue ground. The pattern is printed upon the cloth with the oxide of a metal which yields its oxygen easily to other substances, such as *copper* and *zinc;* the goods are afterwards dyed blue by passing them through the vat; but the parts upon which these metallic salts are printed, resist the dye, by a process

which will be presently described, so that the piece, when finished, is a blue ground with a white pattern. But after the blue vats have been wrought for some time, they cannot be used for this purpose, owing to the weakness of the indigo, and consequently the length of time necessary to keep in the goods to produce the required shade. So that these *resist pastes* are in a manner washed off, and the pattern spoiled. Now, in place of throwing out as useless, vats thus exhausted, *as was formerly done*, the cloth is dyed blue without resists, and after being slightly scoured and washed, they are passed through a strong solution of chromate of potash, and dried in the shade; the required pattern is then printed on the cloth with a mixture of oxalic and tartaric acids (see *Acids*) made into a paste by gum or clay. The potash in union with the chromic acid is taken up by these acids, and the chromic acid being set at liberty, acts on the indigo, and a white pattern is produced. This ingenious process was discovered by a German chemist.

The following table exhibits the composition of those substances which we have briefly described as resulting from the action of nitric acid and chlorine upon indigo. It may be required for reference:—

Name.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Chlorine.	Water.
Indigo,* - - -	16	5	2	1	0	0
Isatine, - - -	16	5	4	1	0	0
Isatinic acid, - -	16	5	4	1	0	1
Anilic, or indigotic acid,	14	4	9	1	0	1
Picric, or carbazotic, acid,	12	2	13	3	0	1
Chlorindoptin, - -	16	4	2	0	4	0
Chlorisatin, - -	16	4	3	1	1	0
Bichlorisatin, - -	16	4	3	1	2	0
Chloranile, - -	6	0	2	0	2	0
Valerianic, - - -	10	9	3	0	0	1

* See chapter V, Part III., and chapter III., Part IV.

K.

KERMES are the dried bodies of the female insects of the species *coccus iliets*, which lives upon the leaves of the *quercus ilex* (prickly oak). The word *kermes* is Arabic, and signifies little worm.* In the middle ages, this dye stuff was therefore called *vermiculus* in Latin, and *vermilion* in French. It is curious to consider how the name *vermilion* has since been transferred to red sulphuret of mercury.†

The principal varieties of kermes are the *coccus quercus*, the *coccus polonicus*, the *coccus fragariæ*, and the *coccus uva ursi*. The *coccus quercus* insect lives in the south of Europe upon the kermes oak. The female has no wings, is of the size of a small pea, of a brownish-red color, and is covered with a whitish dust. From the middle of May to the middle of June the eggs are collected, and exposed to the vapor of vinegar, to prevent their incubation. A portion of eggs is left upon the tree for the maintenance of the brood. In the department of the Bouches-du-Rhone, one half of the kermes crop is dried. It amounts annually to about 80 quintals or cwts. and is warehoused at Avignon.

The kermes of Poland, or *coccus polonicus*, is found upon the roots of the *scleranthus perennis* and the *scleranthus annuus*, in sandy soils of that country and the Ukraine. This species has the same properties as the preceding; *one pound of it, according to Wolfe, being capable of dyeing* 10 *pounds of wool;* but Hermstaedt could not obtain a fine color, although he employed five times as much of it as of cochineal. The Turks, Armenians, and Cossacks, dye with kermes their morocco leather, cloth, silk, as well as the manes and tails of

* The first person who spoke of kermes, with tolerable accuracy, was Pièrre de Quiqueran, Bishop of Sénez, in 1550, *de laudibus provinciæ*. The history of this insect is found in a memoir of Nissole, *Acad. des Sciences*, 1714; and particularly in Reaumur's *Memoires pour servir à l'Histoire des Insectes*, tom. IV.

† *Kermes mineral*, may be obtained perfectly pure, by diluting the proto-chloride of antimony with solution of tartaric acid, and precipitating the metal with sulphurreted hydrogen; or by exposing the finely levigated native sulphuret to a boiling solution of carbonate of potash for some time, and filtering the liquor while boiling hot. The kermes falls down in a brown-red powder, as the liquor cools.

their horses. The kermes called *coccus fragaria*, is found principally in Siberia, upon the root of the common strawberry. The *coccus uva ursi* is twice the size of the Polish kermes, and dyes with alum a fine red. It occurs in Russia. Kermes is found not only upon the *lycopodium complanatum* in the Ukraine, but upon a great many other plants.

Good kermes is plump, of a deep red color, of an agreeable smell, and a rough and pungent taste. Its coloring matter is soluble in water and alcohol:

Acids	Yellowish brown.
Alkalis	Violet or Crimson.
Alum	Blood-red.
Copperas and Tartar . .	Lively gray.
Sulphate of copper and Tartar .	Olive green.
Tartar and Salt of Tin . .	Lively cinnamon yellow.
Alum and Tartar . . .	Lilac.
Sulphate of zinc* and Tartar .	Violet.
Copperas	Blackens it.

Scarlet and crimson dyed with kermes, were called *grain colors;* and they are reckoned to be more durable than those of cochineal, as is proved by the brilliancy of the old Brussels tapestry. Hellot says that previous to dyeing in the kermes bath, he threw a handful of wool into it, in order to extract a blackish matter, which would have tarnished the color. The red caps for the Levant are dyed at Orleans with equal parts of kermes and madder; and occasionally with the addition of some Brazil-wood. Cochineal and lac-dye have now nearly superseded the use of kermes as a tinctorial substance.

On applying to these insects the processes employed by M. M. Pelletier and Caventon in the analysis of cochineal, M. Lassaigne obtained analogous results. It hence appears, that kermes has a chemical composition, very analogous to that of cochineal.†

Kermes has been known in the East since the days of Mo-

* White Vitriol. An explanation of all these terms will be found in the Appendix.

† *Annales de Chimie et Physique*, XII. 102.

ses: it has been employed from time immemorial in India to dye silk; and was used also by the ancient Greek and Roman dyers. Pliny speaks of it under the name of *coccigranum*, and says that there grew upon the oak in Africa, Sicily, &c., a small excrescence like a bud, called *cusculium;* that the Spaniards paid with these grains, half of their tribute to the Romans; that those produced in Sicily were the worst; that they served to dye purple; and that those from the neighborhood of Emerita in Lusitania (Portugal) were the best.

L.

LAC, LAC-DYE.—*Stick-lac* is produced by the puncture of a peculiar female insect, called *coccus lacca* or *ficus*, upon the branches of several plants; as the *ficus religiosa*, the *ficus indica*, the *rhamnus jujuba*, the *croton lacciferum*, and the *butea frondosa*, which grow in Siam, Assam, Pegu, Bengal, and Malabar.* The twig becomes thereby incrusted with a reddish mammelated resin having a crystaline-looking fracture. The female lac insect is of the size of a louse; red, round, flat, with 12 abdominal circles, a bifurcated tail, antennæ, and 6 claws, half the length of the body. The male is twice the above size, and has 4 wings: *there is one of them to* 5000 *females.* In November or December the young brood makes its escape from the eggs, lying beneath the dead body of the mother; they crawl about a little way, and fasten themselves to the bark of the shrubs. About this period the branches often swarm to such a degree with this vermin, that they seem covered with a red dust; in this case, they are apt to dry up, by being exhausted of their juices. Many of these insects, however, become the prey of others, or are carried off by the feet of birds, to which they attach themselves, and are transplanted to other trees. They soon produce small nipple-like incrustations upon the twigs, their bodies being apparently glued, by means of a transparent liquor, which goes on in-

* Kerr and Roxburgh have described this insect in the *Philosophical Transactions*, 1781, 1791. Geoffroy also has given some interesting observations upon the subject, but which are not applicable here, in *Mem. de l'Academie*, 1714.

creasing to the end of March, so as to form a cellular texture. At this time, the animal resembles a small oval bag, without life, of the size of cochineal. At the commencement, a beautiful red liquor only is perceived, afterwards eggs make their appearance; and in October or November, when the red liquor gets exhausted, 20 *or* 30 *young ones bore a hole through the back of their mother*, and come forth. The empty cells remain upon the branches. These are composed of the milky juice of the plant, which serves as nourishment to the insects, and which is afterwards transformed or elaborated into the red coloring matter that is found mixed with the resin, but in greater quantity in the bodies of the insects, in their eggs, and still more copiously in the red liquor secreted for feeding the young. After the brood escapes, the cells contain much less coloring matter. On this account, the branches should be broken off before this happens, and dried in the sun. In the East Indies this operation is performed twice in the year; the first time in March, the second in October. The twigs incrusted with the radiated cellular substance constitute the *stick-lac* of commerce. It is of a red color, more or less deep, nearly transparent, and hard, with a brilliant conchoidal fracture. The stick-lac of Siam is the best. The stick-lac of Assam ranks next; and last that of Bengal, in which the resinous coat is scanty, thin, and irregular. According to the analysis of Dr. John, stick-lac consists, in 120 parts, as follows:—

1.	An odorous common resin	80.00
2.	A resin insoluble in ether	20.00
3.	Coloring matter analogous to that of cochineal	4.50
4.	Bitter balsamic matter	3.00
5.	Dun yellow extract	0.50
6.	Acid of the stick-lac (laccic acid)	0.75
7.	Fatty matter like wax	3.00
8.	Skin of the insects and coloring matter . .	2.50
9.	Salts	1.25
10.	Earths	0.75
11.	Loss	4.75
		120.00

Mr. Hatchett, in a memoir on lac, published in the Philosophical Transactions, for 1804, states the composition of stick-lac* to be, Coloring extract, 20; Resin, 136; Vegetable gluten, 11: Wax, with a little coloring extract, 12; Extraneous substances, 13. 200 grains of seed-lac yielded him only 5 of coloring matter; and 500 of shellac, only 2·5. Mr. Hatchett in that memoir states, that the coloring extract of lac is insoluble in ether, scarcely soluble in alcohol, and slightly so in water, but readily in sulphuric acid, forming a deep brownish-red solution, which being diluted with water, and saturated with potash, soda, or ammonia, becomes changed to a deep reddish purple. Strong acetic acid dissolves it with great ease, and forms a deep brownish-red solution. The lixivia of potash, soda, and ammonia, act powerfully on this substance, and almost immediately form perfect solutions, of a beautiful deep purple color. Pure alumina put into the aqueous solution does not immediately produce any effect; but upon the addition of a few drops of muriatic acid, the coloring matter speedily combines with the alumina, and a beautiful lake is formed. Mr. Bancroft states, that muriatic acid does not answer so well as sulphuric, in preparing the lac dye.

Muriate of tin, says Mr. Hatchett, produces a fine crimson precipitate, when added to the aqueous solution. A similar colored precipitate is also formed by the addition of solution of isinglass. Probably the tannin thus indicated was afforded by the small portions of vegetable bodies, from which the stick-lac can seldom be completely separated.†

Seed-lac.—When the resinous concretion is taken off the

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* According to Franke, the constituents of stick-lac are, resin, 65·7; substance of the lac, 28·3; coloring matter, 0·6.

† Twenty grains of borax, dissolved in 4 ounces of water, form a liquid capable of dissolving 100 grains of shellac. This solution of lac in water, mixed with various colors, as vermilion, fine lake, indigo, Prussian blue, sap-green, or gamboge, forms an excellent vehicle for their application to paper, since, when it dries, the color cannot be removed with a moistened sponge. The Indians make an ink by mixing the above vehicle with lamp-black.—Berthollet on Dyeing, vol. II., p. 416.

twigs, coarsely pounded, and triturated with water in a mortar, the greater part of the coloring matter is dissolved, and the granular portion which remains, being dried in the sun, constitutes *seed-lac*. It contains of course less coloring matter than the stick-lac, and is much less soluble. John found in 100 parts of it, resin, 66·7; wax, 1·7; matter of the lac, 16·7; bitter balsamic matter, 2·5; coloring matter, 3·9; dun yellow extract, 0·4; envelopes of insects, 2·1; laccic acid, 0·0; salts of potash and lime, 1·0; earths, 6·6; loss, 4·2.

In India the *seed-lac* is put into oblong bags of cotton cloth, which are held over a charcoal fire by a man at each end, and, as soon as it begins to melt, the bag is twisted so as to strain the liquefied resin through its substance, and to make it drop upon smooth stems of the banyan tree (*musa paradisa*). In this way, the resin spreads into thin plates, and constitutes the substance known in commerce by the name of *shellac*.

The Pegu stick-lac, being very dark-colored, furnishes a shellac of a corresponding deep hue, and therefore of inferior value. The palest and finest shellac is brought from the northern *Circar*. It contains very little coloring matter. A stick-lac of an intermediate kind comes from the Mysore country, which yields a brilliant lac-dye and a good shellac.

Lac-dye is the watery infusion of the ground stick-lac, evaporated to dryness, and formed into cakes about two inches square and half an inch thick. Dr. John found it to consist of coloring matter, 50; resin, 25; and solid matter, composed of alumina, plaster, chalk and sand, 22.

Dr. Macleod, of Madras, says, that he prepared a very superior lac-dye from stick-lac, by digesting it in the cold in a slightly alkaline decoction of the dried leaves of the *Memecylon tinctorium*, (perhaps the *M. capitellatum*, from which the natives of Malabar and Ceylon obtain a saffron-yellow dye). This solution being used along with a mordant, consisting of a saturated solution of tin in muriatic acid, was found to dye woolen cloth of a very brillint scarlet hue.—(See chapter I. Part IV.)

LAKES.—Under this title are comprised all those colors

which consist of a vegetable dye, combined by precipitation with a white earthy basis, which is usually alumina. The general method of preparation is to add to the colored infusion a solution of common alum, or rather a solution of alum saturated with potash, especially when the infusion has been made with the aid of acids. At first only a slight precipitate falls, consisting of alumina and the coloring matter; but on adding potash, a copious precipitation ensues, of the alumina associated with the dye. When the dyes are not injured, but are rather brightened by alkalis, the above process is reversed; a decoction of the dye-stuff is made with an alkaline liquor, and when it is filtered, a solution of alum is poured into it. The third method is practicable only with substances having a great affinity for subsulphate of alumina; it consists in agitating recently precipitated alumina with the decoction of the dye.

Red lakes.—The finest of these is *carmine.* This beautiful pigment was accidentally discovered by a Franciscan monk at Pisa. He formed an extract of cochineal with salt of tartar, in order to employ it as a medicine, and obtained, on the addition of an acid to it, a fine red precipitate. Homberg published a process for preparing it, in 1656. Carmine is the coloring matter of cochineal, prepared by precipitation from a decoction of the drug. Its composition varies according to the mode of making it. The ordinary carmine is prepared with alum, and consists of *carminium* (see *Cochineal*), a little animal matter, alumina, and sulphuric acid.—(See *Carmine.*)

Carminated lake, called lake of Florence, Paris, or Vienna. For making this pigment, the liquor is usually employed which is decanted from the carmine process. Into this, newly precipitated alumina is put; the mixture is stirred, and heated a little, but not too much. Whenever the alumina has absorbed the color, the mixture is allowed to settle, and the liquor is drawn off. Sometimes alum is dissolved in the decoction of cochineal, and potash is then added, to throw down the alumina in combination with the coloring matter;

but in this way an indifferent pigment is obtained. Occasionally, solution of tin is added, to brighten the dye.*

Madder lake.—Diffuse 2 pounds of ground madder in 4 quarts of water, and after a maceration of ten minutes, strain and squeeze the grounds in a press. Repeat this maceration, &c., twice upon the same portion of madder. It will now have a fine rose color. It must then be mixed with 5 or 6 pounds of water and half a pound of bruised alum, and heated upon a water bath for three or four hours, with the addition of water as it evaporates, after which the whole must be thrown upon a filter cloth. The liquor which passes is to be filtered through paper, and then precipitated by carbonate of potash. If the potash be added in three successive doses, three different lakes will be obtained, of successively diminishing beauty. The precipitates must be washed till the water comes off colorless.

For the following process of making lake from madder, the Society of Arts voted Sir H. C. Englefield their gold medal :—

1. Enclose two ounces troy, of the finest Dutch Crop madder, in a bag of fine and strong calico, large enough to hold four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water, cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it; and when the water is loaded with color, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be found sufficient.

2. Heat all the liquor in an earthen or silver vessel till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum, dissolved in a pint of boiling soft water, has been previously put; stir the mixture together, and, while stirring, pour in gently about an ounce and a half of a saturated solution of subcarbonate of potass. Let it stand till cold to settle; pour off the clear yellow liquor; add to the precipitate a quart of boiling soft water, stirring it well, and, when cold, separate by filtration. The lake should weigh half an ounce.

If less alum be employed, the color will be somewhat deeper; with less than three-fourths of an ounce, the whole of the coloring matter will not unite with the alumina. Fresh madder root is equal, if not superior, to the dry. Almost all

* A lake may be obtained from kermes, in the same way as from cochineal; but now it is seldom had recourse to.

vegetable coloring matter may be precipitated into lakes, more or less beautiful, by means of alum or oxide of tin.

Brazil-wood lakes.—Brazil-wood is to be boiled in a proper quantity of water for 15 minutes; then, alum and solution of tin being added, the liquor is to be filtered, and a solution of potash poured in as long as it occasions a precipitate. This is separated by the filter, washed in pure water, mixed with a little gum water, and made into cakes. Or, the Brazil-wood may be boiled along with a little vinegar, the decoction filtered, alum and salt of tin added, and then potash-ley poured in to precipitate the lake. For 1 pound of Brazil-wood, 30 to 40 pounds of water, and from 1½ to 2 pounds of alum, may be taken, in producing a deep red lake; or the same proportions with half a pound of solution of tin. If the potash be added in excess, the tint will become violet. Cream of tartar occasions a brownish cast.

Yellow lakes are made with a decoction of Persian or French berries, to which some potash or soda is added; into the mixture a solution of alum is to be poured as long as any precipitate falls. The precipitate must be filtered, washed, and formed into cakes, and dried. A lake may be made in the same way with quercitron, taking the precaution to purify the decoction of the dye-stuff with buttermilk or glue. After filtering the lake it may be brightened with a solution of tin. Annotto lake is formed by dissolving the dye-stuff in a weak alkaline ley, and adding alum water to the solution. Solution of tin gives this lake a lemon yellow cast; acids a reddish tint.*

LITMUS is prepared in Holland from the species of lichen called *Lecanora tartarea*, *Roccellatartarea*, by a process which has been kept secret, but which is undoubtedly analogous to that for making archil and cudbear. The ground lichens are first treated with urine containing a little potash, and allowed to ferment, whereby they produce a purple-red;

* *Blue lakes* are hardly ever prepared, as indigo, Prussian blue, cobalt blue, and ultramarine, answer every purpose of blue pigments. *Green lakes* are made by a mixture of yellow lakes with blue pigments; but chrome yellows mixed with blues, produce all the requisite shades of green.

the colored liquor, treated with quicklime and some more urine, is set again to ferment during two or three weeks, then it is mixed with chalk or gypsum into a paste, which is formed into small cubical pieces, and dried in the shade. Litmus has a violet-blue color, is easy to pulverize, is partially soluble in water and dilute alcohol, leaving a residuum consisting of carbonate of lime, of clay, silica, gypsum, and oxide of iron combined with the dye. The color of litmus is not altered by alkalies, but is reddened by acids; and is therefore used in chemistry as a delicate test of acidity, either in the state of solution or of unsized paper stained with it. It is employed to dye marble blue.—(See *Archil.*)

LOGWOOD.—The *Bois de Campeche*, and *Bois bleu*, of the French, and the *Blauholz* of the German dyers. This wood is brought to us from Jamaica and the eastern shores of the bay of Campeachy; on this account it is distinguished in commerce by the names of *Campeachy* and *Jamaica* logwood. The former is considered much superior to the latter, and brings always a higher price in the market. Among botanists the logwood tree is known by the name of *Hæmatoxylon Campechiacum.* In a favorable soil it grows to a great size; its bark is thin and smooth, but is furnished with thorns; its leaves resemble the laurel; its wood is hard, compact, and capable of taking a fine polish; its specific gravity is much higher than water, in which it consequently sinks.

We are not aware who first introduced logwood as a dyeing agent; but its nature, and the art of using it as such, seems to have been but little understood in the reign of Queen Elizabeth; for we find her government issuing an enactment entirely forbidding its use. The document is curious, and affords good proof of the absurdity of a government interfering with the rights of the subject in matters of which it is ignorant. The act is entitled, "An Act for the abolishing of certeine deceitful stuffe used in dyeing of clothes;" and it goes on to state that, "Whereas there hath been brought from beyond the seas a certeine kind of stuffe called logwood, alias blockwood, wherewith divers dyers;" and "Whereas

the clothes therewith dyed, are not only solde and uttered to the great deceyte of the Queenes loving subjects, but beyond the seas, to the great discredit and sclaunder of the dyers of this realme. For reformation whereof, be it enacted by the Queene our Soveraygne Ladie, that all such logwood, in whoes handes soever founde, shall be openly burned by authoritie of the maior." This act was put forth in the 23d year of the Queen's reign, and was renewed again in the 39th, with the addition, that the person so offending was liable to imprisonment and the pillory.* Upwards of eighty years elapsed before the real virtues of this dyeing agent were acknowledged; and there is no dye-wood we know now so universally used, and so generally useful.

Like many other valuable substances, logwood was long used before anything was known of the real nature of the coloring principle. Chevreul, an eminent French chemist, made a chemical examination of the wood, and found it to contain a distinct coloring substance, which he called hematine (which see), a name which has since been changed to hæmatoxylin, to avoid any confusion with the hæmatin of the blood. Logwood contains, besides this coloring matter, resin and oil, acetic acid, and a double salt of potash and lime, with a vegetable acid. It sometimes contains also sulphate of lime, a little alumina, peroxide of iron, and oxide of manganese. These ingredients, however, vary; some woods having more than others, and others wanting some of the ingredients altogether. This variousness of constitution, no doubt, arises from the varying qualities of the soil on which the wood is grown; but the quantity of some of the mineral ingredients has frequently a baneful effect upon light shades, giving to the dye a great tendency to darken, or in dyers' language, to *sadden* the color.—(See chapter II., Part III., article *Purity of Water*.)

* It should be remarked in extenuation of this ungracious interference that the dyers of the good Queen's time were incapable of producing any fast color with logwood; and, therefore, presuming that only fugitive colors could be produced by its use, for the honor and credit of the Queen's most loving subjects forbade the use of the pernicious stuff.

Chevreul's process for procuring the coloring matter is, by subjecting logwood, after grinding, to digestion, for a few hours in water, at 120° or 130° F., afterwards filtering the liquor and evaporating to dryness; what remains is put into strong alcohol for a day; this is again filtered, and the clear liquor evaporated till it becomes thick; to this is added a little water, and evaporated anew; it is then left to itself, and the coloring matter crystalizes.

An improvement on this method has been recommended by Erdmann. The extract of logwood, being evaporated to dryness, is pulverized and mixed with a considerable quantity of pure silicious sand, to prevent the agglutination of the extract, and the whole allowed to stand several days with five or six times its volume of ether; the mixture being often shaken, the clear solution is poured off and distilled until there is only a small syrupy residue. By this means most of the ether is saved; and this being mixed with a certain quantity of water, is allowed to stand for some days, when the hæmatoxylin crystalizes out, and may be dried between folds of blotting paper.

We are afraid both of these processes will be too tedious for adoption in a dye-house. We have seen some very good specimens of the hæmatoxylin obtained by evaporating a strong decoction of logwood nearly to dryness, and allowing it to stand for several days; a solid matter settles to the bottom, having a syrupy fluid above it; large crystals of hæmatoxylin appear to grow from the crust, giving it, when removed, a most beautiful velvety appearance. The crystals vary in length from ¼th to ⅘ths of an inch. They dissolve readily in hot water, but very slowly in cold; the matter is also soluble in alcohol. When dissolved in distilled water, the solution has a beautiful rich wine color; but, when the least trace of lime or iron is present in the water, (and very few waters are free of these) its color is materially altered. The action of reagents is very powerful. Potash, when first put in, colors the solution violet; but this speedily passes into a purple, becoming brownish-yellow; and in a little time, the mixture becomes almost colorless. The reason of this final change is,

that a quantity of oxygen is absorbed; the hæmatoxylin is thereby destroyed, and the caustic alkali converted into a carbonate from the decomposition of the coloring matter. Caustic soda has a similar effect; but the carbonate of soda is much more mild in its action than carbonate of potash.

The action of ammonia on hæmatoxylin, is similar to that of potash and soda, but much more powerful in regard to its changing color, and less destructive upon the substance. Some beautiful and also amusing experiments may be performed with ammonia and the coloring matter of logwood. If a jar full of distilled water be taken, and a few drops of a solution of hæmatoxylin be added, not so much as give a perceptible coloring to the water; in adding a few drops of ammonia, the water instantly takes a reddish tint, and changes so rapidly, that in two minutes, if the jar is large, the color is so dark a violet shade, that the light can hardly be transmitted; in a little it becomes redder, and gradually passes away. This experiment may be repeated by placing the jar simply in the fumes of ammonia; the water begins to color at the top, and as the absorption goes on, the color passes gradually down, so that when it is dark at the top it is slightly tinged at the bottom; and so on till the whole is converted into a dark violet, seemingly by magic.

Erdmann has been able to collect this compound of hæmatoxylin and ammonia, and finds that the coloring matter absorbs three equivalents of oxygen under the influence of the ammonia, and is converted into a substance which he names *hæmatein*. This hæmatein combines with ammonia, and forms a violet black powder which is soluble in water, giving it an intense purple color which spontaneously fades and passes away by keeping.

The action of the alkalies upon logwood is similar to those described upon its coloring matter, and suggests the cause why those who add a little alkali to their logwood liquor while dyeing black, on purpose to give the color of the logwood a richness, and prevent the action of the iron upon it, *invariably have a gray bad black*. Stale urine, indeed, which is most generally used for this purpose, if not used cautiously, produces

the same bad color from the ammonia which it contains. For this reason, also, when lime is used to pass the cloth through after being impregnated with iron, we always wash from the lime, *otherwise the lime on the cloth causes the coloring matter to undergo similar changes with the other alkaline substances, and gives the blacks thus dyed a grayish appearance.*

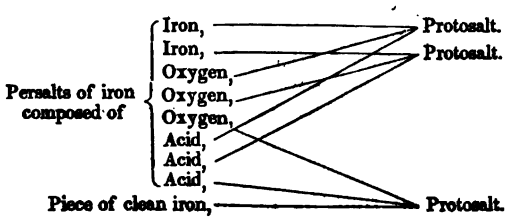
The action of metallic oxides upon the coloring matter of logwood, is somewhat similar to the action of these oxides on logwood itself, varying considerably with the dissolving menstrua of the oxide and the particular state of oxidation, as the following show:—

1. Protosalts of iron	Blue-black.
2. Permanent protosalts of iron . .	Jet-black, becoming brown.
3. Neutral protosalts of tin . .	Rich wine color.
4. Permanent persalts of tin . . .	Deep wine color, becoming brownish.
5. Acetate of lead	Brownish black, becoming bluish.
6. Acetate of copper	Greenish black, becoming brownish.

These are the principal metallic salts used with logwood and their effects. The acids in which the oxides are dissolved affect materially the results obtained; the iron is used as the sulphates or acetates; the tin as chlorides; lead and copper as acetates. The *protosalts* give, with logwood, *the most brilliant, and also the most permanent colors.* The iron protosalts, if exposed to the air, pass very readily into the state of persalts, especially if the salts be neutral—that is, have no more acid than is combined with the oxide. A little free acid prevents this change, but generally produces bad effects. However, where the use of a protosalt of iron is necessary, any persalt in the mordant may be reduced to the proto-state *by the immersion in it of a piece of clean iron, a few hours previous to using the solution.** When an iron salt becomes peroxidised by exposure to the air, every third atom is precipitated as an insoluble oxide—the acid leaving this atom, and combining with two atoms iron, and three oxygen, to form a persalt, which is composed of three

* See chapter I. Part III., article, *Iron.*

acid, three oxygen, and two iron. When a piece of iron is put into a persalt solution, the following reaction takes place :—



This operation ought to be performed just previous to using, and as little exposed as possible ; for when the salt is all converted into the proto-state, the atmosphere again speedily destroys it.

Decoctions of logwood are prepared in the dye-house, either by boiling or *scalding :* if the logwood be chipped or cut, it requires to be boiled for two or three hours. This generally gives the purest and finest colors for *plumb-tubs.** When the wood is ground, the decoctions are generally made by pouring boiling water upon it. Some put the quantity required into a tub ; fill this with boiling water ; allow the grounds to settle, and decant the solution ; but the best method is to use a basket, lined with cloth ;—the logwood is put into the basket, and boiling water poured upon it ; the clean decoction filters through. No more logwood should be taken than what is to be used at the time, as it loses its dyeing properties by standing ; the color passes from a rich wine-hue to a yellow brown ; and assumes a syrupy appearance ; and colors dyed by it after this change takes place, *are always wanting in brilliancy*—they, besides, take a greater quantity to produce the same depth of shade. Parkes in his chemical essays, has the following observations bearing upon this subject :—

Considerable advantage is derived by the woolen dyers from the use of water in the preparation of rasped logwood. As the wood is cut into chips, they sprinkle

* See chapter I. Part III., article, *Tin ;* see also chaper IX. Part III., article, *Processes of Dyeing Black.*

it abundantly with water, and in that moistened state it is thrown into large heaps, and sometimes into bins of great size, where it is suffered to lie as long as is convenient. By this treatment, the chips become heated, or they ferment, as the dyers call it, and thus undergo a very remarkable change; for, after having lain a few months in this state, they give out the coloring matter in the dyeing copper much more easily; and any given quantity of such chips will produce a more intense dye than could have been obtained from an equal quantity of chips which had not been thus heated. It is difficult to account for this, unless we suppose that the water becomes in part decomposed, and that its oxygen, uniting with the vegetable coloring matter, renders it more intense.

We have found that, by damping the wood with boiling water a little before pouring the necessary quantity of boiling water upon it, the wood, in the language of the dyer, is much better *bled;* but we considered this to result from softening the particles of wood, making the coloring matter more easily dissolved by the water afterwards applied. Whether anything more is effected by the practice noticed by Mr. Parkes, or if any decomposition takes place, we cannot say. If, by fermentation, is meant the formation of acids, we know that acids do not produce the effects stated; but if it is a fermentation, caused by the decomposition of any substance having nitrogen as a constituent, the result would be the formation of ammonia, a substance, as we have already noticed, which has a powerful influence upon the coloring matter of logwood, and extracts it very rapidly—a property possessed, indeed, by all alkalies and alkaline earths. This is well known to dealers in logwood, who occasionally sprinkle it with water containing a little lime, which gives the wood a richness in color, so that the poorest woods thus *doctored*, appear equal to those of the finest quality. Such wood, however, never produces good light shades, neither does that coming through the operation of fermentation. The presence of an alkali may be detected in logwood, *by taking a little in a tumbler, and allowing it to steep for a few hours in distilled water, and then trying the solution with delicate test papers.*

The means we have usually adopted for testing the quality of the logwood to be purchased, were by comparing results. The samples to be tried were put into a stove to dry; then half an ounce of each was carefully weighed and put into

separate jars, and an equal quantity of boiling water poured upon them; a measured quantity of each was taken, and an equal weight of cotton dyed. Having always by us some of the best samples, we were enabled to tell pretty accurately the value of the article, and seldom had to complain that we had been disappointed in the one selected.

We have already stated that if a logwood decoction be quite cold, protochloride of tin does not precipitate it, but that, if protochloride of tin be added to hot water, a good deal of the tin is precipitated; the chloride of tin is decomposed, and there is formed a compound of oxide and chloride of tin which is insoluble, forming the precipitate. This decomposition sometimes takes place if the chloride of tin be neutral and added to cold water. This can be prevented by the addition of a little muriatic acid to the salts of tin, but it cannot be done with that which is to be mixed with logwood without deteriorating the mixture. This decomposition of the chloride of tin, is, we think, the cause of the logwood being precipitated, if warm, by the addition of the tin; and the mixture of oxide and chloride formed has a very strong attraction for logwood. The decomposition and combination with the logwood is simultaneous, forming an insoluble compound, very different from that of the soluble chloride and logwood (formed when the logwood is cold) constituting the plumb-tub. It is this property of the decomposition of the salts of tin, when diluted with water, which renders it so desirable as a mordant.

Taking the foregoing observations in connection with what has been stated in chapters I., and II., Part III., we think the dyer will have no difficulty, even with a common share of intelligence, of becoming a perfect master of his business, at least so far as the dyeing of black is concerned.

M.

MADDER.—This substance rivals indigo in value as a dye drug, both from the beauty and permanence of colors it produces. It is the root of a plant or shrub named the *rubia*

tinctorium, that grows naturally in the Levant, Italy, southern parts of France, and in Switzerland. It is cultivated to a great extent in Holland. Its culture has been often attempted in England, but without success. This plant was well known to the ancient Greeks and Romans, and was much used by them as a dyeing agent, and in medicine.

It is the root of the madder that is used for dyeing; it requires to be three seasons in the ground before fully grown. The roots when fully grown are about the thickness of a common quill. When properly dried, if they are broke or cut with a knife, they present to the eye a red yellowish color, which assumes a dense brownish red color when moistened; but the more yellowish the root appears when dry, the more available is the coloring matter. Madder when fresh in the root, and after being cut and ground to powder, in which last state it is used by the dyer, gives off a heavy sweet smell with a slight earthy flavor. Madder *of a bitter, stale, or sour smell*, is invariably of inferior quality.

Madder has been subjected to a great many chemical investigations, the study of which is highly useful to those who use this dye drug in their operations. The first investigation into the chemical properties of madder, led to the discovery of two distinct coloring matters which it contains; one yellow, which is very soluble in cold water, and was named *Xanthin;* the other red, moderately soluble in hot water, and is extracted in considerable purity by sulphuric acid; it is called *Alizarine*. Several methods of extracting alizarine by sulphuric acid have been proposed; the following is probably the most easily practiced:—

One pound weight of madder is mixed with an equal weight of concentrated sulphuric acid, the vessel so closed up that no heat is evolved, and allowed to stand in a cool place for three or four days. By this process, all the constituents of the madder are converted into charcoal, except the alizarine. When this charring process is completed, it is carefully dried, and then digested in alcohol, which dissolves the alizarine, and leaves the charcoal. The solution may now be diluted with water, and the whole put into a retort and kept at a heat of 170°. the beak of the retort being connected with a receiver, the alcohol distils over, and is recovered; water and alizarine remain in the retort, which being filtered, the alizarine remains upon the filter in a state of great purity. It is of a beautiful red color, and communicates the same color to boiling water.

Alizarine is soluble in turpentine, naptha, and fat oils. Chlorine turns it into a yellowish brown; sulphuric acid dissolves it, and at the same time enlivens the color; muriatic and nitric acids both dissolve it, changing the color from red to yellow. Alkalies give it a violet color; alumina forms with it a deep red-brown precipitate; oxides of tin the same. Phosphate of soda has a very powerful attraction for alizarine, *hence the reason that those animals who take madder into their system, have their bones dyed of a red color.* This fact has been long known to practical dyers who use madder in their operations.

From the above facts, it was conceived that alizarine constituted the true coloring matter of madder; and means were then adopted to separate this coloring matter from the vegetable, and use it pure; but it was afterwards found that a fixed dye could not be obtained by pure alizarine, and it therefore was not the true coloring matter of madder. This led to further investigations, from which it appears that madder contains five different coloring matters which have been named,—*madder purple, madder red, madder orange, madder yellow,* and *madder brown.*

Madder purple is obtained by the following process:—

1. The madder is washed in water at about summer heat: then boiled in a strong solution of alum for an hour, the clear liquor is afterwards decanted, and sulphuric acid added, which precipitates the madder purple with a number of impurities. 2. These are removed by washing in boiling water, then with pure muriatic acid, and afterwards dissolving in alcohol.

Madder purple is soluble in hot water, and if pure, gives the water a dark pink color. If the water contain lime, a part of the madder purple is precipitated as a dark reddish brown substance. Cotton saturated with the acetate of alumina is dyed a *bright red*, if the quantity of madder purple be not in excess; when it is so, the color will have more of a *purple cast.* A boiling solution of alum forms with the madder purple, a cherry red solution. Caustic potash forms with it *a fine yellowish red color.* Carbonate of soda and potash affect it in the same manner. Sulphuric acid produces *a bright red color or dark rose.*

Madder red is separated from madder purple, in consequence of its not being soluble, in a strong solution of alum. It is obtained by boiling madder in a dilute solution of alum, when a reddish-brown precipitate is obtained. This is repeatedly boiled in pure muriatic acid, then well washed with water, and boiled in alcohol. This dissolves madder red, and madder purple. The alcoholic solution is evaporated and allowed to cool, when there is deposited an orange-yellow precipitate; this is repeatedly boiled in a strong solution of alum. So long as the solution becomes colored, the insoluble portion is madder red. It is a yellowish brown powder, and imparts to cotton impregnated with the aluminous mordant, *a dark red color* when in excess; but if the cotton be in excess, *a brick-red color* is produced. Caustic potash forms a violet-purple solution; carbonate of soda a red liquid; sulphuric acid a brick-red solution.

Madder orange is obtained from the two former coloring matters by its little solubility in alcohol. It is obtained by macerating madder for twenty-four hours in distilled water, the infusion strained off and allowed to repose for a few hours, the liquor carefully decanted and filtered through paper, the madder orange remains upon the paper; it may be washed with cold water, and afterwards purified by spirits of wine in which it is not soluble. It is a yellow powder; imparts to cotton, impregnated with an aluminous mordant, *a bright orange color*. When in excess, a boiling solution of alum forms with madder orange an orange-yellow solution; caustic potash, a dark rose color; carbonate of soda, orange color; sulphuric acid, an orange-yellow color.*

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* Mr. John Twindells, of Manchester, obtained a patent, in June, 1844, "for improvements in dyeing and producing color." These improvements consist in preparing (when madder, madder root, and munjeet is used) the madder in the following way:—"Take any given quantity of madder and reduce it to a fine powder, then mix it with as much of a solution of caustic ammonia, potash, or soda, as will thoroughly carbonize the yellow or fawn coloring matter therein; different kinds of madder will require varying proportions. The best French madder will require one-eighth part of its weight of caustic alkali, or of ammonia, as much of the solution as will be equivalent in saturating a given weight of an acid, as one-

Madder yellow is characterized by its easy solubility in water; it is a yellow gummy mass; communicates to mordanted cotton *a pale nankeen color*, but does not of itself form a true dye. Madder which contains much of this is inferior in quality, as the yellow becomes so incorporated with the other colors as to materially deteriorate them, and to require several operations to free the goods from it afterwards. Madder brown is a brownish-black dry mass, is of no importance as a dye-stuff, and does not enter into any of the colors dyed by madder; is neither soluble in water nor alcohol.

Besides these five coloring matters, madder contains two acid substances named *Madderic acid* and *Rubiacic acid*, which have no dyeing properties, and therefore are not to be detailed further than to show the intimate knowledge which chemists possess of this agent, so important were any investigation upon madder considered, that the *Société Industrielle de Mulhouse* for several years offered 2000 francs as a premium for the best analytical investigation of this substance.

It will be observed in the brief outline of the five coloring matters of madder, that only three of them are of importance to the dyer. It will also be observed, that these three coloring substances have a similarity of action upon *mordanted cottons*,

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eighth of potash. The powdered madder, when mixed with any of these solutions, is exposed to a heat not exceeding 175° Fahr.; it is then dissolved in water, and is ready to be used in dyeing, or forming madder lakes or pinks.

"If preferred, the madder may be first treated with sulphuric acid, as in making garancine, and the alkali afterwards applied. By this method the operation of heat upon the alkalies will not be required, but they may be dissolved in a solution of any of the alkalies, or their carbonates, or other salts thereof:" for these purposes the patentee prefers the caustic solution of ammonia, as producing the best effects.

"Cotton and linen fabrics which are required to be dyed with the prepared madder, or with the common kinds, or even with other vegetable matters, are prepared in the following manner:—After the fabrics are bleached, and thoroughly cleansed from impurities, they are steeped in a solution of gelatine or albumen, of a specific gravity of 1·04, for several hours; they are then removed, and steeped in a strong solution of tannin for twelve hours; after which they must be wrung out and thoroughly dried. This process may be repeated, or not, according to the depth of color required; and the usual process of dyeing may be proceeded with in the ordinary way." The patentee claims "the use of ammonia, or other alkalies, for preparing a madder dyeing liquor;" but this, we think, he will have some difficulty in holding.

taken singly; not one of them forms a good dye, but they constitute the elements which, together, produce the richest and most permanent red that we are in possession of; therefore, speaking practically, it is only necessary here to consider madder as having only two coloring matters—the one *dun* or *yellow*, which constitutes the impurity of madder, and which the dyer endeavors to get rid of. This coloring matter does not combine with the cloth alone, but it has a powerful attraction for the other coloring matters, and combines with them when on the cloth, and has to be separated by after processes. The other, a *red* coloring matter, which includes the madder red, orange, and purple, for they unite with mordanted cotton as one, and are known to the practical dyer as one. This coloring matter is very difficult to dissolve in water, has no strong decoction, can be obtained by boiling, which makes it less useful in the fancy dye-house, not being very applicable in compound colors; indeed, many extensive dye-houses do not rank madder as belonging to their province; and where it is used in a fancy dye-house, it is generally to give a peculiar tint to light *drabs* and *fawns*, and for dyeing light *salmon* color. When deep colors are to be dyed with madder, the goods must be put into the dye-bath along with the madder.*

* Mr. Frederick Steiner, an English dyer, obtained a patent, in August, 1843, for the manufacture of *garancine* from refuse madder, formerly thrown away, as being exhausted of its dyeing principle. His process, or method of operating, is as follows:—Outside the dye-house a large filter is constructed by sinking a hole in the ground, and lining it at the bottom and sides with bricks without mortar. Upon the bricks is placed a quantity of stones or gravel, and above is placed a common wrapping, such as that used for sacks. Below the bricks is a drain to take off the water from the filter. In a tub adjoining the filter is placed a quantity of dilute sulphuric acid—sp. gr. 105, water being 100. Hydro-chloric acid also answers the purpose; but the other is preferable. A channel is made from the dye-vessels to the filter, and the madder which has been employed in dyeing, and which is in the state technically called *spent*, is run from the dye-vessels to the filter; meantime, such portion of the sulphuric acid is run in, and mixed with it, as changes the color of the solution and the undissolved madder to an orange tint. The action of the acid is to precipitate the coloring matter which is held in solution, and to prevent the undissolved madder from fermenting. When the water has drained from the madder through the filter, the residuum is taken out and put into bags. These are placed in a hydraulic press, and the water is as far as possible expressed from their contents. Still, however, from one half to two-thirds of

GENERAL OBSERVATIONS ON MADDER, &c.—We shall conclude this article with a few observations on the different brands, and on the adulteration of madders, and the best methods of detecting them.

I. As to the brands or marks on madder casks, it is difficult to give positive information on the subject, especially since quackery has endeavored to deceive by extraordinary names. Originally only the following marks were known :—

Mulle.
FF, Fine fine.
SF, Superfine.
SFF, Superfine fine.

These marks were put upon the casks without other designations. The tint alone decided to what sort of root the powder belonged. At present the madders are either—

Palus,* or
Rosy, or
Half Palus, half rosy.

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the remaining weight is water. The compressed material is next passed through a sieve. Into 5 cwt. of the madder in this state, and placed in a wooden or lead cistern, is added 1 cwt. of the sulphuric acid of commerce, by sprinkling it on the madder through a lead vessel similar in form to the common watering-can used by gardeners. The contents of the cistern are then well worked together with a species of rake; and are next placed upon a perforated lead plate, placed about five or six inches above the bottom of the vessel. Between this plate and the bottom of the vessel a current of steam is introduced, so that it passes through the perforated shelve, and the madder which rests upon it. During this process, which occupies from one to two hours, a substance is produced of a dark brown color approaching to black. This substance is garancine and insoluble in the carbonates. The whole material is then spread upon a floor to cool; when cold it is placed upon a filter and washed with cold water, until the water passing from it is not perceptibly acid. It is then put into bags, and a second time subjected to pressure by the hydraulic press. It is then dried, and ground to a fine powder under ordinary madder stones, and afterwards passed through a sieve. To neutralize any acid which may remain, four or five pounds of dry carbonate of soda is added to every cwt. and intimately mixed. The garancine is then ready for use.

* The best madder is made with the roots of the Palus. In Avignon the name of *Palus* is given to some tracts of land anciently covered with marshes; these lands, enriched by animal and vegetable remains, are eminently suited for the cultivation of the madder, and the roots they produce are almost all *red*, whilst other kinds of soils produce rose colored roots.

When it is wished to denote that a madder is all *Palus*, a P is added to the mark. The following are the actual marks:—

Mulle, without distinctive marks.

FF	To each of these marks the letter
SFF	P is added for Palus,
SFFF	R for Rosy,
EXTF	PP for Pure Palus,
EXTSF	RPP for Pure Red Palus,
EXTSFF	Half Palus, Half Rosy, without distinction.

According to these designations, it is by no means rare to find the absurd marks of

EXTSFRPP,

which is to be understood thus:—

Extra Superfine Fine Pure Red Palus.

It must be confessed that such absurdities can only exist in a country where fraud has made revolting progress. It often happens that the mark EXTSF, now used, is not equal to the old one of SFF. The *extra fine* is especially manufactured with the heart, or the ligneous part of the root. This mark gives less depth, because the ligneous part is not so rich in coloring principle as the fleshy part, or the bark of the root, but it affords a much more lively color. The madders of Avignon are packed in deal casks of 900 kilogrammes in weight. The insides of these casks are generally lined with very thick pasteboard, in order to prevent contact with the air, which blackens the powders, causes them to appear less beautiful, and after a certain time destroys much of their tinctorial properties. Light also is very injurious.

It is rather difficult to ascertain exactly the quantity of madder gathered each year in France, as well in Alsatia as in the ancient county of Venaissin. In 1837, the crop of the Lizaris amounted in these districts, to 1,200,000 kilogrammes,*

* The kilogramme is equal to 2lb. 3oz., or 4·428 drams avoirdupois weight. See the articles *Weight* and *Measure* in the Appendix.

which is equivalent to from 48,000 to 50,000 barrels, of which part was sent to the different places where it is consumed, as well within as without the country, conformably to the following table:—

	Kilogrammes.
Rouen, Havre, and Dunkirk,	3,800
Antwerp,	500
Genoa and Leghorn,	183
London, Liverpool, and Glasgow,	3,760
London, Liverpool, and Glasgow, 8000 bales of lizari, which represent,	3,500
Hamburgh,	530
St. Petersburgh,	1,608
Odessa,	110
Rotterdam,	423
Trieste,	205
New York and Boston,	812
Mulhausen, Strasburg, Metz, and Basle, for the consumption of Alsatia, Prussia, Switzerland, Bavaria, Austria, &c.,	15,000
Total,	30,481

There remained, therefore, of the harvest of 1837, at Avignon, and in the department, from 18,000 to 20,000 barrels, when the harvest of 1838 was about to be got in. This, although less than the former, amounted to between 36,000 and 40,000 barrels. The manufacture at Avignon is always in a prosperous condition. The state of the customs shows that in 1840 there was exported from France, 2,161,158 kilogrammes lizaris, which represent in value 1,620,869 francs, and 12,114,054 kilogrammes of madder, equal to 12,114,054 francs; that in 1841 there were exported 1,896,416 kilogrammes of lizaris, equal to 1,422,312 francs, and 11,840,886 kilogrammes of madder, equal to 10,840,886 francs. The importation of foreign lizaris and madders is very small, on account of the heavy duties. The lizaris chiefly come from the Levant by way of Turkey, the Bar-

bary States, from Tuscany, the two Sicilies, and from Germany. The madders come especially from Holland and Belgium.

II. On account of the high price of madder, and especially, from the facility of introducing into this substance foreign pulverulent matters, which the most practiced eye cannot detect, it is often adulterated. There are two kinds of adulteration; sometimes earthy or mineral substances, are incorporated with the madder, and sometimes vegetable substances are added to it, the color of which resembles that of madder.

Adulteration by Mineral substances.—The mineral substances which have been introduced, or which are still found in ground madders, are brick dust, red and yellow ochre, yellowish sand, yellowish clay, or argillaceous earth. A madder which contains earthy substances, grates between the teeth, when chewed. A small quantity of such a madder, for example, from 25 to 30 grammes,* introduced into a large glass globe, and diluted with 5 or 6 litres† of water, quickly deposits the greater portion of the earthy substances at the bottom of the vessel. When the suspended madder is decanted, and the deposit agitated with a fresh quantity of water, the earthy substances are isolated, and may be examined.

To determine the proportions, however, more exactly, processes must be had recourse to. The best is that of calcining, at a red heat, in a platinum crucible.

5 grms., (about 77 grains Troy), of the madder under examination, are first dried completely at 212° Fahr. and are weighed with great exactness, and then put into the platinum crucible, which must be weighed beforehand. The crucible is then shut, and heat gradually applied. When perfectly incinerated, the crucible is taken out of the furnace, and left to cool, and then weighed. Its weight being deducted from

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* A *gramme* is equal to 15 1-2 Troy grains.

† A *litre* is equal to about 60 cubic inches, or 2 1-8 wine pints.—(See Appendix, articles *Weight* and *Measure*.)

the quantity employed, the difference gives the proportion of the cinders obtained.

These cinders are composed, 1st, of the fixed mineral matters contained in the root; and 2nd, of the earthy substances, foreign to the chemical constitution of the root, and which have been accidentally, or fraudulently mixed with the madder.

Some experiments made by M. M. Giradin and Labillardière on a large scale, in 1838, went to prove that madder which is very pure, and quite free from epidermis, or any foreign earthy matter, and dried with care, gives, by incineration, 5 per cent. of ash; that the lizaris of Provence, stripped of its pellicle, gives, on an average, 8·80 per cent. of ash.

According to M. Henri Schlumberger, 100 parts of Alsatian lizaris, washed in distilled water, and dried at 212° Fahr. give 7·20 per cent. of ash; whilst 100 parts of lizaris of Avignon, prepared in the same way, give 8·766.

According to M. Chevreul, 100 parts of lizaris, from the Levant, dried at 212°, give 9·80 ash.

When an Avignon madder, SFF, (the mark most generally used;) subjected to the test of incineration, gives a greater weight of ash than 5 per cent., which has been taken as the average of numerous experiments made by French chemists, the excess must be attributed to the presence of foreign earthy, or sandy, matters, either arising from adulteration, or a careless preparation of the powder.

When the excess is only from three to four-hundredths, it is probably owing to some fault in the preparation of the madder, the manufacturer not having separated the epidermis, which is always coated with the earth that surrounds the root, carefully enough by grinding; but when the excess is above 4 or 5 per cent., or more, it is the result of fraud.

The madders obtained from the merchants give very variable results, with respect to the proportion of ash which they furnish, as the following table shows:—

	Per Cent. of Ash.
On 6 trials the mulle madder of Avignon gave	4·00
On 7 trials the madder SF of Avignon gave from	12·40 to 20·00
On 18 trials the madder SFF of Avignon gave from . .	7·40 to 23·00

	Per Cent. of Ash.
On 4 trials the madder SFFRP of Avignon gave from . .	12·00 to 16.00
On 3 trials the madder SFFP of Avignon gave from . .	10·00 to 10·80
On 7 trials the madder EXTF of Avignon gave . . .	10·00

When, in testing a madder by incineration, the quantity operated on amounts to 5 grammes (about 77 grains Troy), the weight of the ash must be multiplied by 20, in order to bring it to 100 parts, and from the figure obtained 7 parts, representing the mean weight of ash p. c. furnished by good madder, subtracted; the surplus then represents the proportion of earthy matters, or sand, added by the manufacturer. Consequently a madder furnishing 16·40 per cent. of ash will contain 9·40 per cent. of foreign matter.

III. *Adulteration by Vegetable substances.*—The vegetable substances which are introduced into madders, are powders of little or no value, such as sawdust, almond shells, bran, mahogany wood, sandal wood, fir tree wood, &c. The adulteration by these different substances, is far more prejudicial to the dyer *than that by mineral substances;* for, besides diminishing, like the latter, the quantity of coloring matter of a given weight of madder, they also injure the dye.

Unfortunately, the means of detecting this kind of fraud is not so simple as the process for determining the presence of mineral matters. It is extremely difficult to ascertain with what kind of vegetable substance a madder has been adulterated.

The *first* process consists, in determining the coloring power by means of the colorimeter; the *second*, in determining this coloring power, as well as the solidity and brilliancy of the colors, by an operation of dyeing. The *third* is to ascertain the absolute quantity of the coloring principle in a given sample.

"The different experiments," says M. Giradin, "are always made comparatively, by taking for test a madder prepared with all possible care, and having the same marks as that under examination. As with indigo and other tinctorial substances,* a single experiment is not sufficient; and by reason

* See chapters I. and V. Part II.

of the difficulty there is of correctly verifying the value, or the quantity, of the madders, it is indispensable, in order to decide with any certainty, to check the experiments by each other. This is the only way of obtaining satisfactory results."

1. *Determination of the Coloring Power by the Colorimeter.*—The following is the mode of operating:—The test madder, and the madder under examination, are dried at 262° Fahr., and an account is kept of the respective quantities of hygrometric water they contain. 25 grammes (387½ grains Troy), of each sample are mixed with 250 grammes (3375 grains Troy) of water at 68°. After three hours of contact, the whole is thrown upon a linen cloth. A second maceration is made with the same amount of water, and for the same length of time. The madders are then washed with 250 grammes of cold water, dried at 212°, and weighed, in order to ascertain the proportions of soluble, saccharine, and mucilaginous matters which they have lost by these preliminary washings, which only remove a trifling quantity of red coloring matter.

5 grammes (15½ grains Troy) of each of the two madders are then introduced into little glass globes with 40 parts of water, and 6 parts of very pure alum, boiled for a quarter of an hour, and the boiling liquids filtered. The grounds are washed with 2 parts of hot water. Two other decoctions, similar to the first, are made, and each time the residue is washed with 2 parts of hot water. The products of the three decoctions are combined, and the liquids from the two samples of madder compared by the colorimeter.

2. *Determination of the Tinctorial Power by Dyeing.*—In order to determine the value of a madder by dyeing, a test sample of superior madder must be taken, and it should be taken from a cask which had been used, previously, in dyeing cotton goods. By acting with determinate quantities of madder, cloth, and water, correct results may be had. Patterns of calico, intended for comparison, should be prepared in the following manner:—

Ten samples are cut from a piece of calico mordanted for red and black. These are well cleansed in a dung bath. Each of the samples is about 5 centimetres* square (2 inches), and are dyed with proportions of madder, increasing progressively from 1 gramme (7¼ grains Troy) up to 10 grammes (31 grains Troy), so as to have a scale of 10 shades, of which the gradations represent each a known weight of madder. The maddering of these pieces is effected in the following manner:—In a large copper basin with a flat bottom, which is covered with a layer of hay, are placed 10 glass jars with wide mouths, containing from 1½ to 2 litres each (the litre, as before stated, is equal to 2¼ wine pints). The basin is filled with water heated to 104° Fahr. A sample of the calico is now put into each of the jars, the madder weighed with care, and lastly, three-fourths of a litre of distilled water, the whole to be heated to 104° Fahr. A thermometer is now inserted in the water bath (in which the glass jars are placed) which is heated slow enough for the water not to reach 167° Fahr. until an hour and a half after the samples have been introduced, as above stated; avoiding carefully variations of temperature. At the expiration of the hour and a half, the temperature is raised, and the water bath is made to boil for half an hour. The samples are now taken out, rinsed in cold water, and dried. Each sample is then cut in two; one half is preserved as it is, and the other half is subjected to the following clearings:—A soap bath at 122° Fahr. is first given. This bath is made up with 2½ grammes (38¼ grains Troy) of white soap, to each litre (2¼ wine pints) of water. After it has been half an hour in this bath, it is to be carefully rinsed in cold water. A fresh soap bath is now given, to which is added half a gramme (7¼ grains Troy) of salt of tin, and is kept at the boiling point for half an hour. It is then washed and rinsed. The samples are now to be dried with care and preserved from the light.

When a series of tints of two different states have been thus prepared, that is to say, a dye *with* and *without* clearing, it is very easy to ascertain the comparative value of an unknown madder. Whatever vegetable powders may have been fraudulently introduced into the madders, whether tinctorial or inert, *they can never lead to error as to the true tinctorial value of the mixture*, inasmuch as the colors which they afford, and which saturate the mordants at the same time as the red principle of the madder, cannot withstand the action of the clearings as the latter does; they *run*, as is said, in the soap and tin baths, and in the end there only remains the color from the madder upon the cloth. The clearings, are, therefore, necessary to show the solidity and vivacity of the tints obtained.

The foregoing test with samples of calico, is that which has

* A *centimetre* is the hundredth part of a metre, the metre being 39¼ inches English.

been employed in France since 1831. It differs very little from the method published in 1835, by M. H. Schlumberger, of Mulhausen.*

3. *Determination of the quantity of the coloring principle.*—M. Giradin gives us the following method, which, he says, he has been long accustomed to employ:—50 grammes, (3872¼ grains Troy) are diluted with 50 grammes of concentrated sulphuric acid. The whole is left in contact for some hours: too high a temperature should be avoided; the charcoal obtained is mixed with water, and thrown upon a filter; it is then washed until the water passes through quite insipid; and next dried at a temperature of 212° Fahr., in Gay-Lussac's water bath. This charcoal is reduced to a fine powder, and macerated for two hours at three distinct intervals, with cold alcohol containing a little ether, in order to free it from a fatty matter which it retains. The madder is boiled in alcohol of 0·834, at three different intervals, employing each time about 250 grammes of alcohol. When this is no longer colored by ebullition, the alcoholic liquors are mixed, and distilled in a small glass retort to the consistence of a syrup, and the concentration of the liquid completed in the water bath in a weighed porcelain crucible. When the extract is perfectly dry, its weight is taken. This represents the proportion of red tinctorial principle contained in the madder.

This process is rather long; it does not give, especially on a small scale, the absolute proportion of coloring principle contained in the madder; there is a slight loss, but by acting comparatively a sufficient approximation is obtained. Such are the methods for ascertaining the quality, the purity, or the adulteration, of madders by the French. In most cases, calcination is sufficient. Calcination and the test by dyeing made conjointly, allow the practitioner to form a correct estimate of the value of the madders submitted for examination.

Considering the minutiæ, and the number of operations which it is necessary to have recourse to, in order to form a

* Bulletin de la Société Industrielle de Mulhausen, VIII. p. 309.

just estimate of the relative worth of madders, it is evident that an examination by simply looking at them, as is customary with the merchants, can afford no precise information, and must, indeed, lead, in most cases, to erroneous conclusions. The method practiced by the French merchants in testing the qualities of the madders, is, to spread samples of about a quarter of a pound side by side on a clean linen cloth or large sheet of paper. These little heaps are flattened or rendered smooth on the top with an ivory spatula. The samples are then placed in a cellar, or some moist situation, where they are kept from twelve to fifteen hours. At the expiration of this time the quality is judged of according to the brightness and tint of the respective samples.

This method does not, however, even approximately show the richness of color of the madders, since a somewhat long contact with the air is sufficient to render them darker, and many circumstances may change their tint, without thereby causing their tinctorial value to vary. On the other hand, the old madders, of a dull tint, may be far superior to new ones of a more beautiful color. The merchants and brokers method of trial often places the manufacturer in a false position, by obliging him to brighten the tint of his powders, in order to make them more saleable, and that sometimes to the injury of the tinctorial power; thus facilitating the adulteration of the madders by mixture with foreign substances, suitably colored and pulverized, which serve to heighten the tint of the powder; and it is impossible to ascertain the presence of these mixtures by exposure in the cellar.

M. Giradin purposely made a mixture of madder, mahogany, and sandal wood, in known proportions, and this mixture when submitted to merchants, who thought themselves very skillful in the estimation of the value of madders by the foregoing process, was considered by them to be pure madder of first quality!

N.

NICARAGUA-WOOD.—(See *Brazil-wood.*)

P.

PEACHWOOD.—(See *Brazil-wood.*)

Q.

QUERCITRON, is the inner bark of a tree (the *Quercus nigra* of botanists). Its dyeing properties were first made known by Dr. Bancroft, in 1784. Two years after, he obtained an act of parliament, vesting in him the exclusive use and application of it for a certain term of years. This dye drug contains a good deal of tannin, and a yellow coloring matter which has got the name of *Quercitrin.* It is crystalline, and has a pearly lustre. Bark was extensively used in the dye-house for many years for the purpose of dyeing yellow, and almost completely superseded the use of fustic both from its beauty and also its cheapness; but its use for that purpose has been superseded by the bichromate of potash.* Its principal use *now* in the best French as well as English and Scotch establishments, is to form the ground for *browns,* and for dyeing *green* upon light muslin cloth.

The quantity of tannin combined with this wood, makes it very useful for *olives;* goods impregnated with iron, and passed through a decoction of bark take *a beautiful olive.* The proper mordant for this dye is *pyrolignite of alumina. Alum* and *chloride of tin* make also an excellent mordant. In dyeing greens upon cotton cloth, the goods are impregnated with pyrolignite of alumina, and then put through a decoction of the bark: but in dyeing *light* shades of green, much attention must be paid to the preparation of the decoction. This is made by pouring boiling water upon the bark. If *deep dark greens are wanted,* this method is best; but if light greens be wanted, the water should not be above 86° or 90° Fahr.; at this heat there is only the finest yellow coloring matter dissolved; but by a higher temperature the tan and other matters are dissolved, and the color obtained be-

* See chapter IV. Part III., article *Processes of Dying Yellow;* see also chapter VI. Part III., article *Processes of Dyeing Orange.*

comes more or less brown. This peculiarity, however, makes it better as an ingredient in browns, olives, &c. For further information upon this subject, the reader must consult the processes described in the body of the work, for obtaining the colors above referred to, all of which are noticed in the *index*. —(See chapter IX. Part III., article *Browns with Quercitron Bark.*)

R.

REDWOOD.—(See *Barwood.*)

S.

SAFFLOWER.—This is an annual plant, cultivated in Spain, Egypt, and the Levant. There are two varieties of it, one having large leaves, and the other smaller ones; the last is the best. It is only the flower of this plant that is used for dyeing. When the flowers are gathered, they are squeezed between two stones to express their juice; they are afterwards washed with spring water; next taken in small quantities and pressed between the hands and laid out upon mats to dry. These cakes are covered up during the day to prevent the sun from shining upon them—which would not only destroy the color, but dry the cakes too much, and thereby cause further deterioration. They are kept exposed to the dews of night, and turned over occasionally till properly dried, when they are packed up for the market. It is in this state they are procured by the dyer.—(See chapter III. Part III., article *Safflower Pink;* see also chapter V. Part III., article *Safflower and Prussian Blue*, and chapter III. Part V., article *Pinks, Crimsons, Roses, &c., with Safflower.*)

SANDAL or RED SAUNDERS WOOD, is the wood of the *Pterocarpus santalinus*, a tree which grows in Ceylon, and on the coast of Coromandel. The old wood is preferred by dyers, who use it pretty extensively, at present, for browns. Its coloring matter is of a resinous nature; and is, therefore, quite soluble in alcohol, essential oils, and alkaline leys; but

sparingly in boiling water, and hardly if at all in cold water. The coloring matter which is obtained by evaporating the alcoholic infusion to dryness, has been called *santaline;* it is a red resin, which is fusible at 212° F. It may also be obtained by digesting the rasped sandal wood in water of ammonia, and afterwards saturating the ammonia with an acid. The *santaline* falls, and the supernatant liquor, which is yellow by transmitted light, appears blue by reflected light. Its spirituous solution affords a fine purple precipitate with the *protochloride of tin*, and a violet one with the *salts of lead.* Santaline is very soluble in acetic acid, and the solution forms permanent stains upon the skin.

Sandal wood is used in India, along with one-tenth of *sapan* wood (the *Cæsalpinia sapan* of Japan, Java, Siam, Celebes, and the Philippine isles), principally for dyeing *silk* and *cotton.* Trommsdorf dyed wool, cotton, and linen, a carmine hue by dipping them alternately in alkaline solution of the sandal wood, and in an acidulous bath. Bancroft obtained a fast and brilliant reddish-yellow, by preparing wool with an alum and tartar bath, and then passing it through a boiling bath of sandal wood and sumac. Pelletier did not succeed in repeating this experiment. According to Vogler, wool, silk, cotton, and linen, mordanted with salt of tin, and dipped in a cold alcoholic tincture of the wood, or the same tincture mixed with 8 parts of boiling water, become of a superb ponceau-red color. With alum they took a scarlet-red; with sulphate of iron, a deep violet, or brown-red.* Unluckily these dyes do not stand exposure to light well.

SAPAN WOOD, is a species of the *Cæsalpinia* genus, to which Brazil-wood belongs. It is so called by the French, because it comes to them from Japan. As all the species of this tree are natives of either the East Indies or America, one would imagine that they could not have been used as dye-stuffs in Europe before the beginning of the 16th century. Yet the author of the article "Brazil," in Rees's Cyclopædia, and Mr. Southey, in his History of Brazil, say that

* Crell's Annals, 1790.

Brazil wood is mentioned nearly one hundred years before the discoveries of Columbus and Vasco de Gama, by Chaucer, who died in 1400; that it was known many ages before his time; and that it gave the name to the country, instead of the country giving the name to the wood.—(See *Brazil-wood.*)

SUMAC, is the powder of the leaves, peduncles, and young branches of the *Rhus coriaria*, and *Rhus cotinus*, shrubs which grow in Hungary, the Bannat, and the Illyrian provinces. Both kinds contain tannin, with a little yellow coloring matter, and are a good deal employed for tanning light-colored leathers; but the first or the *Rhus coriaria*, is the best. With peroxide of iron as the mordant, it imparts a variety of shades from slate color to black. In calico-printing sumac affords, with a mordant of tin, a yellow color; and with sulphate of zinc a brownish yellow. A decoction of sumac reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale yellow flocks with alum; blue flocks with red sulphate of iron, with an abundant precipitate.

Almost all vegetables contain, especially in their bark,* more or less coloring matter, capable of affording dun hues, inclining to yellow, brown, red or green. These coloring matters present greater or less differences among each other, in reference to their quantity and quality; they further vary according to climate and the age of the vegetable. A great diversity of shades, therefore, may be procured, by modifying the dun natural to the vegetables, by means of different mordants. This has been accomplished by Siefferts,† and particularly by D'Ambourney.‡ Thus in a great many experiments which the latter made, employing the parts of different vegetables, and using different mordants, the colors which he produced were, for the most part, between yellow and brown, such as *carmelites*, olives, cinnamons, and ma-

* See chapter II., Part III. † Versuché mit einheinmischen farbe materien.

‡ Recueil des procédéset d'experiénces sur les teintures solides, que nos végétaux indigènes communiquient aux laines et aux lainages.

rones. The decoction of the greater part of vegetables, and especially of barks, affords a color differing only in shade, and exhibits with reagents nearly the same characters. The decoction of walnut peels, however, produces a peculiar effect with solutions of iron; it assumes a very deep color, but no precipitate is formed even after two or three days. Their decoction, as well as that of walnut tree bark, has a powerful action on oxide of iron; it saturates it, forming a black liquor; and even if filings of iron be put into this decoction exposed to the air, in two or three days it forms a black liquor by means of the oxygen which it attracts from the atmosphere. But if a decoction to which solution of sulphate of iron has been added, be boiled, an abundant black deposit instantly falls. It is therefore evident, that it is only in a trifling circumstance that walnut peels as well as walnut-tree bark, differ from the other substances which yield a dun color; yet its extractive matter possesses in particular the property of becoming black by the action of the air, and the pellicles formed when it is evaporated, assume in a very marked degree the appearances of a carbonized substance.

If the yellow color produced by several vegetable substances be compared with the dun which most of them afford, a close relation will be found between these colors. There are even some which may be referred equally to yellow and to dun. As the dun shades obtained from different substances vary to a great extent, sometimes several of these substances are blended in order to obtain a peculiar color, and that in different proportions.* Other ingredients are also mixed with them, to modify their color and to render it faster. Among these substances there is none more worthy of attention, than that of sandal or red saunders wood, just described.—(See chapters I., II., III., and IX., Part III.; see also chapter IV., Part IV., and chapter I., Part V.)

* Berthollet on Dyeing, vol. II., p. 264.

T.

TURMERIC is the root of the *Curcuma longa* and *rotunda*, a plant which grows in the East Indies, where it is much employed in dyeing yellow, as also as a condiment in curry sauce or powder. The root is knotty, tubercular, oblong, and wrinkled; pale-yellow without, and brown-yellow within; of a peculiar smell, a taste bitterish and somewhat spicy. It contains a peculiar yellow principle, called *curcumine*, a brown coloring matter, a volatile oil, starch, &c. The yellow tint of turmeric is changed to brown-red by alkalies, alkaline earths, subacetate of lead, and several metallic oxides; for which reason, paper stained with it is employed as a chemical test. Turmeric is employed by the wool-dyers for compound colors which require an admixture of yellow, as for cheap browns and olives. As a yellow dye, it is employed only upon silk. It is a very fugitive color. A yellow lake may be made by boiling turmeric powder with a solution of alum, and pouring the filtered decoction upon pounded chalk.

TURNSOLE.—(See *Archil*, and *Litmus*.)

W.

WELD is an annual herbaceous plant, which grows all over Europe, called by botanists *Reseda luteola*. The stems and the leaves dye yellow; and among the dyes of organic nature, they rank next to the Persian berry for the beauty and fastness of color. The whole plant is cropped when in seed, at which period its dyeing power is greatest; and after being simply dried, is brought into the market. Chevreul has discovered a yellow coloring principle in weld, which he has called *luteoline*. It may be sublimed, and thus obtained in long needle-form, transparent, yellow crystals. Luteoline is but sparingly soluble in water; but it nevertheless dyes alumed silk and wool of a fine jonquil color. It is soluble in alcohol and ether; it combines with acids, and especially with bases. When weld is to be employed in the dye-bath, it

should be boiled for three quarters of an hour; after which the exhausted plant is taken out, because it occupies too much room. The decoction is rapidly decomposed in the air, and ought therefore to be made only when it is wanted. It produces the following results: with—

Solution of isin-glass	a slight turbidity.	
Litmus paper	a faint reddening.	
Potash ley	a golden yellow tint.	
Solution of alum	a faint yellow.	
Protoxide salts of tin	a rich yellow	precipitation.
Acetate of lead	ditto	precipitation.
Salts of copper	a dirty yellow-brown	precipitation.
Sulphate of red oxide of iron . .	a brown, passing into olive.	

Mr. Partridge, an English dye stuff dealer, 34 Cliff street, New York, is, as will be seen by the following extract from his book on dyeing, completely in love with weld as a tinctorial substance. This dyewood is indeed, as every practical man knows, of great value; but nevertheless, we are not prepared to go to the same extent in its praise, that Mr. Partridge has:—"The color obtained from weld," says he, "is more permanent, with the common mordants alum and tartar, *than any other yellow dye.* The color it gives is also *more delicate than any other;* but its chief superiority consists in the property it possesses, in a very superior degree, of imparting a great degree of softness to the woolens dyed with it. Our manufacturers cannot but be aware of the advantage of using such dyes as will give a softness to their wool, in preference to others, which from astringency have the effect of giving a harsh feeling to their fabrics. So much are European wool dyers impressed with the superiority of weld *over any other yellow dye*, that they use it in all furnace colors that will admit of it, though it costs them *more than double the price of other dyes*, for which it is substituted. The drabs dyed with weld *are more permanent*, and the colors more delicate *than from any other yellow.* The olive-browns and greens, and the bronze greens, *are in every way superior, as it respects their brilliancy and permanency.* When used for wool colors, the wool is found to work softer

and better in every subsequent operation."* Great improvements in the art of dyeing have been made in England, since Mr. Partridge left. Indeed, *one* cannot always know the extent of these improvements, without devoting much time, money, and last, though not least, talent, to the subject. Old Yorkshire dyers have of late years been completely driven out of the market, and their places, in many instances, supplied by Frenchmen.—(See chapters I., II., and IV., Part III.; see also chapters II. and III., Part IV., and chapter II., Part V.)

WOAD, the *glastum* of the ancient Gauls and Germans, is an herbaceous plant which was formerly much cultivated, as affording *a permanent blue dye*, but it has been in modern times well nigh superseded by *indigo*. Pliny says, "A certain plant which resembles *plantago*, called *glastum*, is employed by the women and girls in Great Britain for dyeing their bodies all over, when they assist at certain religious ceremonies; they have then the color of Ethiopians.†" When the arts, which had perished with the Roman empire, were revived, in the middle ages, woad began to be generally used for dyeing blue, and became an object of most extensive cultivation in many countries of Europe. The environs of Toulouse and Mirepoix, in Upper Languedoc, produced annually 40,000,000 pounds of the prepared woad, or pastel, of which 200,000 bales were consumed at Bordeaux. Beruni, a rich manufacturer of this drug, became surety for the payment of the ransom of his king, Francis I., then the prisoner of Charles V. in Spain.

"The leaves of woad," says Berthollet, "are furnished at their edges with small smooth indentations, and of a bluish-green color. The flowers are yellow, disposed in panicles at the summits of the stems. The root is thick, woody, and penetrates deeply into the earth. For its cultivation it requires a good black mould, light, and well improved. It is sown in spring, after a double tillage in autumn. Three or four crops are obtained in a year. The first when the stems

* Partridge on dyeing, p. 48.

† *Hist. Nat.* cap. XXII. § 2.

begin to grow yellow, and the flowers are about to appear; the others at successive intervals of six weeks or more, according to the climate and heat of the season. The plant is mown with a scythe, washed in the river, and dried in the sun. Its desiccation must be rapidly performed; as, if the season be unfavorable, or if it rains, the plant runs a risk of being spoiled. A single night is sometimes sufficient to turn it black."*

The leaves are carried to the mill to be ground into paste, and then piled in heaps to ferment, in order that certain vegetable principles injurious to the beauty of the dye, may be destroyed; as well as to elaborate the indigoferous matter present, before they are brought into the market; but they should be carefully watched during this process. Whenever the leaves have arrived at maturity, a point judged of very differently in different countries, they are stripped of the plant, a cropping which is repeated as often as they shoot, being three or four times in Germany, and eight or ten times in Italy. The leaves are dried as quickly as possible, but not so much as to become black; and they are ground before they get quite dry. The resulting paste is laid upon a sloping pavement, with gutters for conducting the juice, which exudes into a tank; the heap being trampled from time to time, to promote the discharge of the juice. The woad ferments, swells, and cracks in many places, which fissures must be closed; the whole being occasionally watered. The fermentation is continued for twenty or thirty days, in cold weather; and if the leaves have been gathered dry, as in Italy, for four months. When the fermented heap has become moderately dry, it is ground again, and put up in cakes of from one to three pounds; which are then fully dried, and packed up in bundles for the market. Many dyers subject the pastel to a second fermentation.

1,600 square toises (fathoms) of land afford in two cuttings at least 19,000 pounds of leaves, of which weight four-fifths are lost in the fermentation, leaving 3,880 pounds of pastel, in

* Berthollet on Dyeing, vol. II. p. 55.

cakes. When good, it has rather a yellow, or greenish-yellow, than a blue color; it is light, and slightly humid; it gives to paper a pale-green trace; and improves by age, in consequence of an obscure fermentation; *for if kept four years, it dyes twice as much as after two years.* Pastel affords, without indigo, a blue color which has no brilliancy, but is very durable. Woad differs from ordinary pastel, merely in requiring a larger quantity of it to produce a like effect.

Astruc relates, in his memoirs on the natural history of Languedoc, that having treated pastel in the small way as the anil is treated to obtain indigo, he procured a powder which produced the same effects as indigo. Hellot thence concluded, that the deep green of several plants is owing to yellow and blue particles, and that, if by fermentation the yellow could be destroyed, the blue would remain.* But Lewis says, that having made different species of plants putrefy in water, he obtained no blue fecula. "This mixture of blue and yellow molecules," says he, "to form the green of plants, is a supposition void of foundation."† Several attempts have been made in different places to extract an indigo from pastel. It appears that the product is too small for the coloring substance to enter into competition with ordinary indigo.

Gren, gives us the following description, with emendations. of the process by which indigo, or blue coloring matter, is obtained from pastel:—The fresh leaves of pastel are taken and washed, to separate the impurities and the earth. They are then put in an oblong tub, or vat, nearly three-fourths full of water, and to prevent the leaves from being buoyed up, pieces of wood are fixed across on the top. The vessel is now to be moderately heated. The froth on the surface indicates the commencement of fermentation. But this indication will not, of course, make its appearance for several days, being governed by the degree of heat applied, which must be

* See chapter II., Part I.

† The Chemical Works of Gaspar Neumann, by William Lewis.

extremely slight, or the temperature of the atmosphere. Whenever there is a certain quantity of this froth, the liquor, which should be of a deep green tint, is drawn off into another oblong tub or vat, by means of a stopcock near the bottom; and in doing this the liquor should be strained through a cloth, in order to separate its impurities, or the fragments of leaves which might pass over.

The leaves are now to be washed with a little cold water, to detach the portions of coloring matter which may adhere to them, and this washing is to be added to the liquor which has been drawn off. As soon as this is accomplished, lime water is poured into the liquor in the proportion of from two to three pounds for every ten pounds of leaves. The mixture is then strongly agitated to facilitate the separation of the indigo, which is precipitated, or falls down to the bottom of the vessel. To ascertain if the agitation has been continued long enough, a portion of the clear liquor is put into a bottle, on shaking which, it will be seen whether the blue matter has been fully separated; and if not, the liquor must be agitated anew. When the indigo, or blue matter, has been fully extracted, the liquor in the bottle will have a yellowish cast. As soon as the indigo, or blue precipitate, has fairly settled, the yellow liquor should be drawn off, by means of the stopcock, which is placed a sufficient distance from the bottom to prevent the blue matter from being drawn off with the water. In doing this, drawing off the yellow liquor, the vat may be canted a little to one side, to facilitate the operation. The coloring matter is then poured into conical filters of linen cloth, or into large filtering bags, into which a sufficient quantity of water is thrown for the purpose of freeing it from impurities. It is then dried by a gentle artificial heat, taking care to cover it up.

The blue matter may be obtained without the addition of the lime, but not in such abundance. If, however, a larger quantity of lime water be added, more blue matter is obtained, but its quality is inferior; because the surplus of the calcareous earth unites with the indigo. Alkalies likewise facilitate the separation of the blue matter; but it is not

advantageous to employ them, because they afterwards dissolve a portion of the blue substance. With the addition of an acid no precipitate takes place.

A certain time must elapse before it is proper to draw off the water. If it be run off too soon, but little indigo is obtained; if, on the contrary, the leaves be left too long in the infusion with the water, they enter easily into putrefaction, diffusing a fetid and peculiar volatile odor. Thenceforth no more precipitate can be separated, and the water remains permanently green. The same thing happens with the water drawn off, if it be neglected; and, even when the indigo is already separated from the liquor, care should be taken that this do not putrefy. We must not, however, be too hasty in turning the water out of the first vat into the second, the one in which it is to be agitated, on the first appearance of the skin or surface changing blue, since it is at this moment that the leaves give out most of their blue matter.

When the degree of the atmospheric heat is considerable, fermentation is speedily established, and from fifteen to eighteen hours will, in most cases, be sufficient. It is especially requisite then to be very attentive, not to let it run into total putrefaction. If the heat of the atmosphere be too low, neither much froth nor blue pellicle will be perceived, but the liquor will incline gradually to putrefaction, without presenting any marked phenomena before its commencement. It should be remarked, in conclusion, that the blue matter obtained from pastel should, when convenient, be dried artificially, as before stated, but where this cannot be done, it may be dried in the shade, because the sun destroys the color.*

According to Hellot, 4 pounds of Guatimala indigo produced the same effect as 210 pounds of the pastel of Albi. At Quins, in Piedmont, the dyers estimate that 6 pounds of indigo are equivalent to 300 of pastel; but Chaptal thinks the indigo underrated. Fresh woad, analyzed by Chevreul, afforded, in 100 parts, 65·4 of juice. After being steeped in

* Crell; Neueste Entdeckungen. A translation of it is to be found in the Bibliothèque Médico-Physique du Nord, tom. III.

water, the remaining mass yielded, on expression 29·65 of liquid; being in whole, 95·05 parts, leaving 4·95 of ligneous fibre. The juice, by filtration, gave 1·95 of green fecula. 100 parts of fresh woad, when dried, are reduced to 13·76 parts. Alcohol, boiled upon dry woad, deposites, after cooling, indigo in microscopic needles; but these cannot be seperated from the vegetable albumine, which retains a greenish-gray color.

Substitutes for Woad.—Messrs. W. G. & R. Scarth, of Leeds, dyers, "prepare a substance similar to that obtained from woad, from sumac, peat, oak-bark, and the stalks and stems of the hop plant." Their mode of operation is as follows:—

Any given quantity of sumac of commerce, is taken, and sprinkled with water. It is then ground and placed in a heap to produce fermentation, in like manner to the course pursued with the preparation of woad (as stated in the foregoing article); commencing with that part of its process at which it is set to ferment, and the results of such fermentation, when sumac is the material operated on, will be so similar to the like fermentation on woad, that a workman acquainted with the preparation of that substance, will readily judge of the maturity of the process, and when it is ready for the dyer.

In using peat as a substitute for woad, it is pulverized previous to being submitted to the process of fermentation.

In applying oak-bark, or the stalks and stems of the hop-plant, they are, when dry, to be ground into a powder, which is to be treated in a similar manner to the powder or cakes prepared from woad. The material thus produced will then be ready for the dyer, and is to be used in precisely the same manner as heretofore pursued when using the fermented product of woad.

EXTRACTING COLORING MATTER FROM DYE-WOODS.—The coloring matter of dye-woods, may be extracted with great advantage by means of steam, by causing it to pass through the substance to be operated upon, *which*

condenses in its passage and extracts the color; it is then evaporated to any consistency at the pleasure of the operator.

The apparatus which best answers the purpose, in England, is composed of a steam box lined with lead, and covered by a shallow metal pan; a pipe proceeding from a boiler, communicates at one end of the box and filling it with steam, heats the pan and its contents in the course of the process; from the opposite end of the box a second pipe proceeds upwards through the bottom of a wooden chamber, (that is lined with glass or glazed earthenware,) to the distance of about one foot from the top, the lid of this chamber is constructed so as to allow of its being easily opened, and when closed, to remain steam-tight; a quantity of chips of the dye-wood being put in at the top, it falls on a false bottom of perforated tin, and the steam being admitted into the steam box, will find its way through the pipe and fill the space that is left in the chamber; in passing downwards through the dye-wood it condenses, and dripping on the real bottom of the chamber, which is placed on an inclined plane, is conveyed from thence by a small pipe to the shallow pan described. In this situation, the liquor may, if required, be evaporated by means of the steam that is below it,—even to powder if it be necessary. When the liquor flowing from the chamber becomes colorless, the whole of the dyeing properties of the wood has been extracted; the chips, which will be found bleached, may then be removed and a fresh portion operated upon. If the substance employed be of a resinous nature, the vapor of spirits of wine must be used instead of the steam of water.

All the other vegetable dye-stuffs, with the colors which they respectively produce, have been described by D'Ambourney, and republished by Mr. Cooper, in his work on dyeing. Those of our friends who may be desirous of investigating the subject, but who have not Mr. Cooper's work, are informed that it was published at Philadelphia, in the year 1815, by Thomas Dobson, 41 South Second street, where the work may still, for aught we know to the contrary, be had. The accounts of these coloring substances given in the various dye books, and works on domestic economy, of the

present day, have, in ninety-nine cases out of a hundred, been copied, verbatim, et ad literatum, from D'Ambourney's table, Berthollet, and such books as Mackenzie's "Five thousand Recipes."

We have now gone over the principal vegetable dyeing agents;* but as the mineral kingdom has in some instances superseded the vegetable, we shall next proceed to devote a few pages to substances in which the chemical principles of the art will be more easily developed.

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* M. Iwan Shulumberger's recent communication to the Société Industrielle de Mulhausen on the "Extraction of coloring matter from Dye-woods" contains nothing new, and does not therefore merit a place in this work.

CHAPTER IV.

MINERAL COLORING SUBSTANCES EMPLOYED IN DYEING, WITH THEIR PRINCIPAL CHEMICAL CHARACTERS, &c.

Antimony-Orange—Arseniate of Chromium—Cadmium—Chrome-Yellow, or Chromate of Lead—Chrome-Orange, or Subchromate of Lead—Manganese-Brown—Orpiment—Peroxide of Iron—Prussiate of Copper—Prussian Blue—Scheele's Green—Sulphuret of Cadmium.*

A.

ANTIMONY-ORANGE.—This orange-red substance has been applied to cloth by passing the piece through a solution of the sulphuret of antimony (1) and a little sulphur in a caustic alkali, and afterwards exposing it to the air to precipitate the sulphuret, through the absorption of carbonic acid.

1. *Antimony* readily combines with sulphur, and forms a gray sulphuret with metallic lustre. The same compound is found in nature. It may be melted in close vessels without undergoing any change; but when slowly roasted in a shallow vessel, it gradually loses sulphur and attracts oxygen, and may then be melted into a glassy substance, transparent at the edges, and called *glass of antimony*. It consists of eight parts of protoxide, and one of sulphuret.

Dr. Thomas Thomson, of Glasgow, obtained pure antimony, by dissolving the antimony of commerce in nitro-

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* The author has thought it advisable to give in these headings only the titles of the different articles contained in each chapter of the work, to avoid confusion. For a more complete analysis, the reader is referred to the Index, at the end of the work, where the different subjects contained under each of these titles, are more particularly pointed out.

muriatic acid, and precipitating the peroxide by means of water. This oxide was well washed, dried, mixed with black flux, and exposed to a red heat in a covered crucible. The metallic antimony thus obtained was exceedingly soft, and its specific gravity was only 6·424, at the temperature of 60°. This is somewhat below the specific gravity of this metal usually given by chemists.

5·5 grains of this antimony were put into a platinum crucible, and dissolved by the assistance of heat in nitric acid. The solution was evaporated to dryness, and exposed for some hours to a heat of 500°. A yellow colored powder was thus obtained, possessing the properties of peroxide of antimony; it weighed 7·5 grains. Four different trials made by Dr. Thomson in the same way, gave each the same result. Thus it appears that peroxide of antimony is a compound of

Antimony . .	5·5
Oxygen . .	2
	7·5

ARSENIATE (2) OF CHROMIUM.—This is a fine *grass-green* colored compound, which may be imparted to cloth, by the application, first of a solution of chloride of chromium, (3) and afterwards of a solution of arseniate of soda.(4)

2. The *Arsenites* and *Arseniates* which are the only soluble compounds of the arsenious and arsenic acids with the salifiable bases, are those of potash, soda, ammonia, and probably lithia; all the remainder are insoluble in water, but are taken up by an excess of their own acid, and still more readily by nitric acid.

3. *Chromium* was discovered by Vauquelin in 1797. The only ore of this metal, which occurs in sufficient abundance for the purposes of art, is the octohedral chrome-ore, commonly called chromate of iron, though it is rather a compound of the oxides of chromium and iron. The fracture of this mineral is uneven; its lustre imperfect metallic; its color between iron-black and brownish-black, and its streak brown. Its specific gravity, in the purest state, rises to 4·5;

but the usual chrome-ore found in the market varies from 3 to 4. According to Klaproth, this ore consists of oxide of chromium, 43; protoxide of iron, 34·7; alumina, 20·3; and silica, 2; but Vauquelin's analysis of another specimen gave as above, respectively, 55·5, 33, 6, and 2. It is infusible before the blowpipe; but it acts upon the magnetic needle, after having been exposed to the reducing smoky flame. It is entirely soluble in borax, at a high blowpipe heat, and imparts to it a *beautiful green color*. The chief application of this ore is to the production of chromate of potash, from which salt the various other preparations of this metal used in the arts are obtained. The ore, freed as well as possible, from its gangue, is reduced to a fine powder, by being ground in a mill, and sifted. It is then mixed with one-third or one-half its weight of coarsely bruised nitre, and exposed to a powerful heat, for several hours, on a reverberatory hearth, where it is stirred about occasionally. In large manufactories the ignition of the above mixture in pots is laid aside, as too operose and expensive. The calcined matter is raked out, and lixiviated with water. The bright yellow solution is then evaporated briskly, and the chromate of potash falls down in the form of a granular salt, which is lifted out from time to time from the bottom with a large ladle, perforated with small holes, and thrown into a draining-box. This saline powder may be formed into regular crystals of neutral chromate of potash, by solution in water and slow evaporation; or it may be converted into a more beautiful crystaline body, *the bichromate of potash*, by treating its concentrated solution with nitric, muriatic, sulphuric, or acetic acid, or, indeed, any acid exercising a stronger affinity for the second atom of the potash than the chromic acid does.

4. *Arseniate of soda* is obtained with great ease in large crystals; because it is more soluble in hot than in cold water. Mitcherlich has shown that the crystals have the same form as those of phosphate of soda: when exposed to the air the salt speedily effervesces on the surfaces, but does not fall to powder; when heated it undergoes the watery fusion. 100 parts of water at 47° dissolve 22·268 parts of this salt.

Dr. Thomson obtained this salt by mixing solutions of 7·75 parts of arsenic acid and 18 of crystalized carbonate of soda. The salt formed was neutral, and the liquid yielded crystals to the very last drop. 20·75 grains of the crystals, when heated, lose 9 grains of water, equivalent to 8 atoms. Hence the constituents of the salt are obviously.

1 atom arsenic acid	7·75
1 atom soda	4
8 atoms water	9
	20·75

C.

CADMIUM.—(See *Sulphuret.*)

CHROME-YELLOW, or CHROMATE OF LEAD (5).—The color of this pigment is bright yellow; it may be communicated to cloth by the consecutive application of solutions of acetate or *nitrate of lead* (6) and *bichromate of potash* (7); or the oxide of lead may be first fixed on the cloth in an insoluble state, as carbonate, tartrate, or sulphate. It consists of one equivalent of chromic acid and one equivalent of oxide of lead.

5. *Chromate of lead*, the chrome-yellow of the painter, is a rich pigment of various shades, from deep orange to the palest canary yellow. It is made by adding a limpid solution of the neutral chromate, to a solution, equally limpid, of acetate or nitrate of lead. A precipitate falls, which must be well washed, and carefully dried out of the reach of any sulphureted vapors. A lighter shade of yellow is obtained by mixing some solution of alum, or sulphuric acid, with the chromate, before pouring it into the solution of lead; and an orange tint is to be procured by the addition of sub-acetate of lead, in any desired proportion.

6. *Nitrate of lead* is prepared by dissolving litharge, or metallic lead in nitric acid, and evaporating the solution, which leaves a crystaline mass, the crystals of which are white and generally opaque, and soluble in 7½ parts of cold

water. The nitrate of lead, when prepared in this way, contains one proportion of oxide, and one of nitric acid; but by boiling the salt for some time over litharge, the acid will combine with two, three, or even six proportions of lead, forming what are termed *basic* salts.* The fact just stated has been known to practical dyers for some years, and it is made available for the purpose of dyeing *orange* or *dark shades of yellow.*

A solution of nitrate of lead may be partially decomposed by ammonia, so as to form several *subnitrates.* On adding a very small quantity of the alkali a subnitrate is formed, composed of 1 equivalent of acid, and 2 of the base; a little more produces a compound of 1 equivalent of acid and 3 of base, and an excess of ammonia precipitates a salt composed of 1 of acid and 6 of base.

7. The *bichromate,* or *red chromate, of potash,* may be prepared from the yellow chromate by adding a little sulphuric acid to it, which combines with a portion of the potash, leaving two proportions of chromic acid in union with one proportion of potash, which crystalizes in large square tubular crystals of a rich orange-red color. This is the salt used in the arts, not only for dyeing, but for the preparation of other chrome compounds, and is prepared on the large scale in the following manner:—

The chrome iron ore, after being finely ground and sifted, is mixed with a quantity of dried nitre and carbonate of potash. This mixture is thrown into a reverberating furnace, and subjected for several hours to a powerful heat, being occasionally stirred. When perfectly calcined, the mass is raked out and dissolved in water. It is then boiled for several hours, after which the insoluble portion is allowed to settle and the solution decanted, which is evaporated, and leaves crystalized the yellow chromate of potash. The chemical changes which take place in the furnace are these: first, the decomposition of the nitre giving off oxygen, which combines with the oxide of chromium and forms chromic acid; this unites with the potash of the nitre and of the carbonate, and forms the yellow salt which is soluble in water, and afterwards separated as described. It contains also soluble impurities, such as caustic potash, silicate and aluminate of potash, which are separated by the succeeding operations of boiling and crystalization.

The bichromate, which is the salt used in dyeing, is pre-

* See chapter I. Part III., and Appendix, article *Base.*

pared from the yellow obtained as above. Into a concentrated solution of the yellow salt is poured acetic, or sulphuric acid. The sulphuric acid, though often used, is not well adapted for the purpose, as the sulphate of potash formed is most difficult to separate from the chromate, and constitutes a serious adulteration. Acetic acid is preferable, and is now generally employed. The quantity of the acid used is so regulated, that it combines with the one half of the potash in the yellow salt, leaving two proportions of chromic acid in union with the other half; this process may be expressed thus:—

2 Yellow salt	2 chromic acid 1 Potash 1 Potash	Bichromate of potash.
1 Acetic acid		acetate of potash.

The solution of yellow salt being concentrated before the addition of the acid, the bichromate formed has not so much water as to hold it in solution, and is therefore thrown down as an orange colored powder. This is carefully collected, dissolved again in water, and crystalized by slow evaporation.

The bichromate of potash, when sulphuric acid has been used, is sometimes adulterated to about 40 per cent. This is easily detected by dissolving a small quantity of the salt in distilled water, and adding to it pure nitric acid; after which, there is added a little solution of nitrate of barytes. If any sulphate be present, there will be formed on the addition of this salt, *a white precipitate*, insoluble in acids; if any muriate be present, the addition of a solution of nitrate of silver to the salt similarly prepared, *gives a white curdy precipitate.*

Soda is sometimes used instead of potash in the preparation of the salt of chrome, and serves the purpose of the dyer equally well. The combination of chromic acid with other bases is effected by decomposing the bichromate with the salt of the particular base wanted. For example, to prepare the chromate of lead a soluble salt of lead, such as the acetate, is added to a solution of bichromate, a double reaction takes

place, and there is formed a soluble salt of potash, and an insoluble salt of lead.

2 Chromate of lead	2 oxide of lead	Subchromate of lead.
	1 chromic acid	
	1 chromic acid	Chromate of potash.
2 Potash	1 potash .	
	1 potash .	Potash.

This chromate of lead is a rich lemon-yellow powder, which constitutes the chrome-yellow dye. If this powder be digested in hot caustic potash, it is partially decomposed; the potash unites with one proportion of the chromic acid, and there is formed a basic salt of lead thus:—

2 Acetate of lead	1 acetic acid . .	Acetic acid.
	1 acetic acid . .	Acetate of potash
	2 oxide of lead . .	
1 Bichromate of potash	1 potash	Chromate of lead.
	2 chromic acid . .	

CHROME-ORANGE, or SUBCHROMATE OF LEAD (8). This is a dark orange-red pigment, consisting of one equivalent of chromic acid and two equivalents of oxide of lead. To apply it to cotton, the piece is first dyed with *chrome-yellow* (see No. 5, *Chromate of Lead*), and is afterwards passed through hot *milk of lime*,* by which a portion of the chromic acid of the chrome-yellow is separated.

8. The *subchromate of lead*, prepared in the following manner, has a rich vermilion color, greatly superior to that obtained upon cotton generally, by the process of dyeing:—

Having fused a quantity of nitre in a crucible, add gradually dry chromate of lead, so long as effervescence and escape of red fumes take place. The crucible being then taken off and allowed to settle, the melted portion is poured off, leaving the heavy powder at the bottom, which may be washed with a very little water.

M. Dulong's method of preparing subchromate of lead in the moist way is well known. It appears that the product obtained by this process is not of a fine cinnabar red color: it has merely a deep orange shade, but still fine enough to be employed in *dyeing*. It has been found that, by fusing neutral chromate of lead with nitrate of potash, the subchro-

* The *milk of lime* is prepared by mixing lime with water.

mate may be obtained of as fine a red as the best cinnabar.* The nitre is to be fused at a low red heat, and pure chromate of lead thrown into it in small portions at a time. On each addition of the chromate, strong effervescence occurs, occasioned by disengagement of gas, and the mass becomes black, because the chrome red, as it may be technically called, appears black when it is hot. The yellow chromate is to be added until all the nitre is decomposed. Care must be taken not to heat the crucible too strongly, because at too high a temperature the color loses its beauty and becomes brown. The crucible is then to remain for some time, in order that the chrome red, which is heavy, may deposit, and the saline mass, which is composed of chromate of potash and nitre, is to be poured off while fluid. This mass may be used again for the preparation of fresh chromate of lead. The chrome red remaining in the crucible is to be well washed with water, and dried.

It is essential not to leave the saline solution long in contact with the red powder; because by this it loses its splendor, and acquires *an orange tint*. The powder, however, subsides so fast on account of its density and crystaline state, that this inconvenience is easily remedied by increasing the number of washings. The chrome red thus obtained is a powder of a superb cinnabar red color; when it is examined by the light of the sun, it appears to be composed of small crystaline scales. Yellow chromate of lead dissolves plentifully in a strong boiling solution of potash. After some days this solution deposits groups of red crystals composed of small plates, which consist of subchromate of lead, and of neutral chromate. (See chapters IV. and VI., Part III.)

M.

MANGANESE (9) BROWN (Hydrated† Peroxide of Man-

* See Appendix, article *Cinnabar*.

† Formed into a hydrate. A *hydrate* is a compound, in definite proportions, of a metallic oxide with water. Slacked lime is a hydrate of lime.—(See Appendix, article *Anhydrous*.)

ganese).—Cloth is dyed with this substance by being passed, first, through a solution of *sulphate or chloride of manganese* (10); next, through a caustic alkaline solution, to precipitate *protoxide of manganese* (11); and lastly, through a solution of *chloride of lime* (see *Bleaching*), to convert the protoxide of manganese into peroxide (12); or the peroxidation may be effected by mere exposure to air.

9. *Manganese* is a grayish-white metal, of a fine-grained fracture, very hard, very brittle, with considerable lustre, of spec. grav. 8·013, and requiring for fusion the extreme heat of 160° Wedgewood. It should be kept in closely stoppered bottles, under naptha, like potassium, because with contact of air it speedily gets oxidized, and falls into powder. It decomposes water slowly at common temperatures, and rapidly at a red heat. Pure oxide of manganese can be reduced to the metallic state only in small quantities, by mixing it with lamp black and oil into a dough, and exposing the mixture to the intense heat of a smith's forge, in a luted crucible; which must be shaken occasionally to favor the agglomeration of the particles into a button. Thus procured, it contains, however, a little carbon.

10. *Sulphate* and *hypo-sulphate of manganese.*—By passing sulphurous acid through water in which finely powdered peroxide of manganese is suspended, the peroxide yields part of its oxygen to the acid, and converts one portion into sulphuric and another into hypo-sulphuric acid. *Sulphate* and *hypo-sulphate* of manganese are both produced; and by pouring lime into the mixed solution, the oxide of manganese is thrown down with an insoluble sulphate of lime, while a soluble hypo-sulphate of lime is left in solution.

The solution of hypo-sulphate of manganese affords a deliquescent salt by evaporation.—(See Appendix, article *Deliquescent.*)

11. *Protoxide of manganese.*—Considerable uncertainty still exists with regard to the various compounds of manganese with oxygen. The protoxide may be formed by mixing the deutoxide with charcoal, and exposing it to a strong red heat; or by passing a current of hydrogen over the same

oxide heated to redness in a porcelain tube. When pure it is of a green color, but speedily becomes brown from the absorption of oxygen. It may also be produced by dissolving the common black oxide of manganese in sulphuric or nitric acid, adding a little sugar, and precipitating, by solution of potash; a white powder may be thus collected, which is a hydrate, and which, being heated to redness out of the contact of air, gives off its water, and yields the oxide. It takes fire when gently heated, and is converted into the deutoxide.

The deutoxide of manganese is readily procured by exposing the peroxide to a low red heat. It is of a brown color. It presents the anomaly of an equivalent and a half of oxygen united to the metal. When exposed to the air it slowly absorbs oxygen, and returns to the state of peroxide. Both these oxides form the bases of saline compounds.

12. *Peroxide of manganese.*—This compound is found native in abundance, and is used in the arts for discoloring glass, *and for the manufacture of chlorine for bleaching.* It is commonly of an earthy appearance, and mixed with other ingredients; but it is not unfrequently met with in crystals of a black color and metallic lustre. It undergoes no change on exposure to the air. It is insoluble in water, and does not unite either with acids or alkalies. It has the singular property of inflaming linseed oil, when previously well dried and kneaded with it. On exposure to red heat it gives out oxygen, and is converted into deutoxide.

The analysis of the *ores of manganese*, when pure, is exceedingly simple. The operator need only, by well-known methods, determine the water which the ore contains, and the oxygen which it loses in being converted into the red oxide. Its degree of oxidation, on which the commercial value of ores of manganese so essentially depends, may then be readily inferred.

But when impurities prevail, as they almost always do, more or less in commercial manganese, the analytic process is complex and troublesome; and the presence of iron, which is rarely absent, renders an exact result by the ordinary modes of analysis almost impracticable; for, when peroxide

of iron is strongly heated in mixture with peroxide or deutoxide of manganese, oxygen is given out by the former as well as by the latter; and, accordingly, the oxygen lost by heat ceases to indicate the nature of the manganese. A moderately correct allowance for the quantity of oxygen emitted by the iron under these circumstances would be difficult, even after ascertaining in the moist way the quantity of iron contained in the ore; since the constitution of the resulting oxide of iron, as well as its uniformity, is probably variable, and at all events, is undetermined. The chemist would, therefore, have to ascertain separately each constituent of the ore, and consider the loss as oxygen belonging to the manganese,—a method not to be trusted in a complicated analysis, and which would be wholly inapplicable, if the iron, as contained in the ore, should happen not to be uniformly oxidized.

The best method of ascertaining the relative quantities of chlorine which an equal weight of each ore is capable of supplying, consists in dissolving a given weight of the ore in muriatic acid, condensing the chlorine in water, and, by some uniform measure, estimating the quantity of chlorine relatively to an equal weight of pure per-oxide of manganese, selected as a standard of comparison. The substance first used with this intention was a solution of indigo; but a weak solution of green vitriol, employed by Mr. Dalton for ascertaining the strength of bleaching powder, was found to be more precise in its indications.

The method of manipulation is as follows:—

About ten grains of the ore in fine powder is introduced into a flask capable of containing about an ounce of water, and into its neck is fitted, by grinding, a bent tube about two inches long, which conducts the chlorine from the flask into a tube about sixteen inches in length, and five-eighths of an inch wide, full of water, and inverted in a small evaporating capsule, employed as a pneumatic trough. The apparatus being adjusted, the flask is half filled with concentrated muriatic acid, the conducting tube instantly inserted, and heat applied by means of a spirit-lamp. The air of the flask, together with the chlorine, is then collected, the greater part of the latter, if the gas is not very rapidly disengaged, being absorbed in its passage; and, consequently, the receiving tube, at the close of the process, will be about half full of gas. When the ore is completely dissolved, the last traces of the chlorine are expelled from the flask by muriatic acid gas. In order

that the chlorine thus collected may be entirely absorbed, the aperture is closed by a ground stopper, or, still more conveniently, with the finger, and the gas is well agitated until the chlorine is wholly absorbed. As the solution in the inverted tube may become too saturated to dissolve all the chlorine, it is convenient to fill a pipette with pure water, and, with the aid of the mouth, force a current to ascend into the tube, and thereby cause the heavier solution to flow out into the capsule.

The absorption being complete, the solution of chlorine is introduced into a six or eight ounce stoppered bottle, and a dilute solution of green vitriol, made, for example, with a hundred grains of the crystalized salt and a pint of water, is added in successive small quantities until the odor of chlorine just ceases to be perceptible. The quantity of liquid required for the purpose may be conveniently measured in a tube about sixteen inches long, and three-quarters of an inch in diameter, divided into two hundred parts of equal capacity, and supplied with a lip, so that a liquid may be poured from it, without being spilled. In conducting this part of the process, the operator will perceive two odors:—at first, the characteristic odor of chlorine, accompanied with the peculiar irritation of that gas; and subsequently an agreeable, slightly aromatic odor, unattended with irritation. The object is, to add exactly so much solution of iron as suffices to destroy the former of these odors, without attempting to remove the latter, a point which, with a little practice, may be readily attained. The whole of the iron is thus brought into the state of peroxide.

The first trial is generally accompanied with some loss of chlorine, and should only be used as a guide to a second and more precise experiment. Accordingly, a weighed portion of the same ore is dissolved, and the chlorine collected as before, except that the solution of green vitriol, in quantity rather less than sufficient, is at once introduced into the inverted tube and capsule. A more ready and perfect absorption of the chlorine is thus effected, and the subsequent addition of a small quantity of sulphate of iron suffices for completing the process.

The principal sources of error in this method are the two following:—loss of chlorine, by smelling repeatedly, and ex-

posure to the air when the gas is absorbed by pure water, and oxidation by the air when the absorption is made directly by means of the solution of iron. The small flask and inverted tube are apt to retain the odor of chlorine, and should therefore be rinsed out with the absorbing liquid. It should be remembered also, that a given quantity of chlorine will emit a more or less distinct odor, according as it is less or more diluted; but by operating always in the same manner, and employing such weights of different ores, that equal quantities of the solution may contain nearly equal quantities of chlorine, it is easy to be independent of these errors of manipulation, by causing them to affect each experiment to the same degree. It will accordingly be found with a little practice, that results of surprising uniformity may be thus obtained; and even the constitution of pure oxides of manganese may be ascertained by this method, almost with the same accuracy as by directly determining the quantity of oxygen.—(See *Bleaching*, Part II., and Appendix, article *Manganese*.)

O.

ORPIMENT. (Lat. auripigmentum.) Yellow sulphuret *of arsenic;* it forms the basis of the yellow paint, called "king's yellow." The solution of orpiment in ammonia has been used as *a yellow dye*, for silk, wool, and cotton, by first passing the goods through a solution of orpiment in ammonia, and afterward suspending them in a warm atmosphere to volatilize the ammonia and precipitate the orpiment. The dye is, however, rather fugitive. Orpiment is sometimes applied in the form of a solution in a caustic fixed alkali, in which case the precipitation is afterward effected by passing the cloth through dilute sulphuric acid.

The finest specimens come from Persia, in brilliant yellow masses, of a lamellar texture, called golden orpiment. Artificial orpiment is manufactured chiefly in Saxony, by subliming in cast iron cucurbits, surmounted by conical cast iron capitals, a mixture in due proportions of sulphur and arse-

nious acid (white arsenic). Genuine orpiment is often adulterated, and is frequently nothing else than white arsenic combined with a little sulphur, and is quite soluble in water. It is therefore a deadly poison, and has been administered with criminal intentions and fatal effects. A proper insoluble sulphuret of arsenic, like the native or the Saxon, may be prepared by transmitting sulphureted hydrogen gas through any arsenical solution. It consists of 38·09 sulphur, and 60·92 of metallic arsenic, and is not remarkably poisonous. The finest kinds of native orpiment are reserved for artists; the inferior are used for the *indigo vat*. They are all soluble in alkaline leys, and in water of ammonia.

P.

PEROXIDE OF IRON (13) (iron buff).—This oxide is applied to cloth to produce *a yellowish-brown shade* of different intensities, by passing the piece through a solution of a salt of the peroxide of iron, and a solution of an alkaline carbonate, in succession.

13. *Peroxide of iron.**—When iron is dissolved in nitric acid, then boiled for some time, precipitated by ammonia, and exposed to a low red heat, it is converted into peroxide. It is of a red color, and not attracted by the magnet. It is composed of

1 equivalent of iron . .	28
1½ ditto oxygen . .	12
	40

* According to M. Liebig, when carbonate of lime is boiled with a solution of peroxide of iron and protoxide of manganese, the former is precipitated, and the latter remains in solution; the separation is so complete that no trace of iron remains in solution, nor is any manganese precipitated. Carbonate of magnesia may be employed for the same purpose. To determine the precision of this method, one part of protosulphate of manganese was mixed with forty parts of protosulphate of iron, and mixtures were made in inverse proportions; after having peroxidized the iron by nitric acid, the solutions were boiled with carbonate of magnesia. In every case the oxide of iron was completely precipitated, and without a trace of oxide of manganese. The muriates and nitrates of these oxides were similarly treated, and the results were similar, both with the carbonate of lime and with that of magnesia.

The affinity of iron for oxygen is very great. It may be burned in oxygen gas; and, when heated to redness in the open air, it absorbs oxygen rapidly, and is converted into black scales, called the *black oxide* of iron. This is, however, not a definite compound, but a mixture of protoxide and peroxide. The same compound is also produced when the steam of water is brought into contact with red hot iron. The protoxide of iron may be obtained pure by passing dry hydrogen gas over the peroxide at a temperature a little below redness. Its color is a very dark blue. It is attracted by the magnet, but not so strongly as the metal itself. It is very combustible; and, when thoroughly exposed to the air at common temperatures, it spontaneously ignites, and becomes converted into the peroxide. All its combinations are also characterized by this high attraction for oxygen. It is composed of

1 equivalent of iron . .	28
1 ditto oxygen . .	8
	36

We are indebted to M. M. Wohler and Liebig, for the following observations on the combination of the protoxide and peroxide of iron:—

"The perfect success attending the method for obtaining protoxide of copper, rendered it probable that protoxide of iron, which had not hitherto been obtained pure in a separate state, might be procured in the same manner. With this object, sublimed chloride of iron was prepared, by calcining iron wire in muriatic acid gas. This chloride, crystalized in white micaceous scales, was fused at a low red heat with dry carbonate of soda. The residual mass being treated with water, there remained a dense black powder.

"This substance was strongly attracted by the magnet, and dissolved in muriatic acid without evolving any gas: nevertheless it was not protoxide of iron, but a mixture of protoxide and peroxide, as was ascertained by the increase of weight which it acquired by calcination in the air. The

solution of this substance in muriatic acid is yellow; when ammonia is added to it, a black precipitate is formed, which appears brown when it is more divided: it may be filtered and washed in the air without any change of color, that is to say, without becoming a hydrate of the peroxide, as might be expected. After drying, the precipitate is in small brittle pieces of a black-brown color, and of a deep brown when powdered: it is a hydrate of a compound of the protoxide and deutoxide, becoming black and losing its water by heat.

"This hydrate possesses another unexpected property,—that of being attracted by the magnet as strongly as the intermediate compound, or the magnetic iron ore. If a magnet be immersed in the liquid, while the precipitate is in a state of suspension, a great part of it is collected round the magnet.

"Magnetic iron ore acts in a precisely similar way to the artificial substance just described. Some crystals of it were dissolved in muriatic acid, without the contact of air, and the yellow solution was precipitated by ammonia. The same black precipitate was obtained, which did not oxidize more in the air, and was equally magnetic. It is well known that the white precipitate formed by an alkali in a solution of a proto-salt of iron, becomes black when it is boiled in the liquid, and it was apparently admitted that this precipitate was an hydrous protoxide of iron: this is a mistake, *for it is also a hydrate of the protoxide and peroxide formed by contact of the air during ebullition.*

"The white protohydrate of iron is not magnetic, at least while it remains in the liquid. This fact appears surprising, if it be admitted that in the magnetic compounds of oxides of iron the property of being attracted depends upon the quantity of protoxide which they contain. Reasoning in this way, the hydrate of the protoxide ought to be more magnetic than the hydrate of the mixed oxides."

The most distinguished analysts have been occupied with finding a method of separating the oxides of iron. The process proposed by Fuchs is extremely accurate; mixtures of proto- and per-salts of iron are boiled with carbonate of lime;

the peroxide of iron is precipitated in the state of a subsalt, and so completely that the solution is not turned red by the sulphocyanate of potash. The only inconvenience of the process is, that the filtered solution, being perfectly neutral, becomes slightly turbid, owing to the conversion of a small portion of protoxide into peroxide. But this may be avoided by using carbonate of magnesia instead of carbonate of lime; the solution does not become turbid, probably because magnesia forms a more stable double salt with the protoxide of iron.

In some applications this method of separation may be of importance. *Calico-printers* employ pyrolignite of lime to produce very different tints, and these depend upon the proportion of peroxide which it contains, and this is easily determined by the following process:—

Take two equal portions of pyrolignite of lime; one of them is peroxidized by means of a solution of chlorine, or by ebullition with nitric acid; then precipitate by ammonia, which gives the entire quantity of iron dissolved; the other portion is to be boiled with carbonate of magnesia, and then filtered; the protoxide of iron is afterwards converted into peroxide by the means above mentioned, and precipitated by ammonia, after having added a certain quantity of muriate of ammonia to prevent the precipitation of the magnesia. The weights of these two precipitates, after subtracting the second from the first, will give with sufficient accuracy the proportions of protoxide and peroxide.

PRUSSIATE OF COPPER.—A delicate *cinnamon color* is sometimes communicated to cotton by means of this substance, which is applied by first passing the cloth through a solution of sulphate of copper, then through a dilute alkali to precipitate oxide of copper, and lastly, wincing in a solution of yellow prussiate of potash, containing a little muriatic acid.

The solutions of all the salts of copper have a blue color when diluted, and green when concentrated. This alone is sufficient to distinguish them from those of any other metal. A small proportion of potash precipitates, from the sulphate, a green subsalt; but in excess it throws down the black oxide. Ammonia redissolves the precipitate, and a splendid deep blue solution is produced. Ferro-cyanate of potash causes a red or copper-colored precipitate, which is quite characteristic of

the metal. The copper is deposited in the metallic state both upon zinc and iron. The taste of the salts of copper is styptic, and highly nauseous, and they are all poisonous.

PRUSSIAN BLUE.—To apply this pigment, the cloth may be first impregnated with a solution of acetate of iron (iron liquor); and afterwards passed through a solution of yellow prussiate of potash, acidified with a little muriatic acid.—(See chapter V. Part III.)

S.

SCHEELE'S GREEN (arsenite of copper).—This grass-green colored substance may be applied to cloth by the double decomposition of *nitrate of copper*,* and *arsenite of potash*;† the cloth being passed through solutions of these salts consecutively. A better method is, to precipitate oxide of copper on the cloth by the action of an alkali, and to wince the piece afterwards in a solution of arsenite of potash.—(See Appendix, article *Scheele's Green.*)

SULPHURET OF CADMIUM.—This compound may be fixed on silk, to which it gives a beautiful golden color, by first impregnating that substance with a certain quantity of chloride of cadmium, and putting it afterwards in contact with a weak solution of hydro-sulphate of potash or of soda.—(See chapter III. Part V., article *Golden Yellow by Sulphuret of Cadmium.*)

* See Appendix, article *Nitrate of Copper.*

† See Appendix, articles *Arsenic*, and *Arseniate of Potash.*

CHAPTER V.

ACIDS EMPLOYED IN DYEING AND CALICO-PRINTING.

Acetic Acid—Chloric Acid—Chromic Acid—Citric Acid—Malic Acid—Muriatic, or Hydrochloric Acid—Nitric Acid—Nitro-Muriatic Acid (Aqua Regia)—Oxalic Acid—Pyroligneous Acid (or Wood Vinegar)—Sulphuric Acid—Tannic Acid—Tartaric Acid.

A.

ACETIC ACID is the name of the sour principle which exists in vinegar, in which shape it appears to have been known even to remote antiquity. It is mentioned by Moses, nearly 1500 years before the Christian era, (Numb. vi. 3,) and was extensively used by the Israelites, as well as by the Greeks and Romans. It occurs, ready formed, in several products of the vegetable kingdom, and is generated during the spontaneous fermentation of many vegetable and animal juices. The *sambucus nigra*, or black elder, the *phœnix dactilifera*, and the *rhus typhinus* are plants which afford a notable quantity of vinegar. It is found, likewise, in the sweat, urine, milk, and stomach of animals. All infusions of animal or vegetable matters in water, when exposed for some time to the air, at a moderate temperature, ferment into vinegar; and most vegetables, when subjected to decomposition by fire, give off condensable vapors of acetic acid.

It has been long known that, when dry acetate of soda and sulphuric acid are mixed in the requisite proportions, and distilled in a retort, an acetic acid comes over so strong that it crystalizes when cooled down to a low temperature, and remains in crystals as long as the thermometer is lower than 50°. If we have a considerable quantity of the acid in this concentrated state, we have it in our power, by decanting the liquid portion off the crystals, to obtain them in a

state of great purity, and quite dry. It is in this way that crystalized acetic acid is prepared by Mr. Ramsay of Glasgow. By drying these crystals on blotting paper, at a low temperature, they may be freed completely from all adhering liquid, and made as dry as the crystals of tartaric acid.

Dr. Thomson put a quantity of these dry crystals into a phial, and melted them by leaving them for 24 hours in a warm room. The liquid thus obtained did not crystalize, though kept for a long time in a temperature as low as 40°; but if we raise it to the temperature of 45°, and throw into it a single crystal of acetic acid, a number of crystaline spiculæ dart out with rapidity all over the liquid, and the temperature rises from 45° to 51°. By degrees, after this commencement of crystalization, the whole liquid assumes the solid form, although the temperature be not lower than 45°.

These crystals, while in a liquid state, and at the temperature of 60°, have a specific gravity of 1·06296.

The same gentleman dissolved 22·125 grains of these crystals in water, and added to the solution 26·25 grains of anhydrous carbonate of potash, obtained by exposing bicarbonate of potash to a red heat. This addition just neutralized the acid, for the mixture produced no change upon the color of litmus or cudbear paper. If we divide each of the substances employed by 3, the consequences meant to be drawn from the experiment will be plainer.

$$\frac{22{\cdot}125}{3} = 7{\cdot}375\text{; and}$$

$$\frac{26{\cdot}25}{3} = 8{\cdot}75$$

We may say, then, that 7·375 grains of crystals of acetic acid were just neutralized by 8.75 grains of anhydrous carbonate of potash; but 8·75 grains of this carbonate contain just 6 grains of potash, which is equivalent to an atom. Consequently, 7·375 grains of the crystals of acetic acid must contain just 6·25 grains of real acetic acid; for that is the quantity requisite to saturate 6 grains of potash. The re-

mainder of the weight of the acid is obviously water, and it amounts to 1·125, which is equivalent to an atom of water. Thus it appears that the crystals of acetic acid are composed of

1 atom real acid . .	6·25
1 atom water . .	1·125
	7·375

By dissolving given weights of these crystals in water, and taking the specific gravity of the solutions at 60°, Dr. Thomson was enabled to form the following table, exhibiting the specific gravity of various atomic compounds of this acid and water:—

ACID		WATER		SP. GR. at 60°
1 atom	+	1 atom	. .	1·06296
1 -	+	2 -	. .	1·07060
1 -	+	3 -	. .	1·07084
1 -	+	4 -	. .	1·07132
1 -	+	5 -	. .	1·06820
1 -	+	6 -	. .	1·06708
1 -	+	7 -	. .	1·06349
1 -	+	8 -	. .	1·05974
1 -	+	9 -	. .	1·05794
1 -	+	10 -	. .	1·05439

We see from this table that the specific gravity of the liquid is a maximum, when it consists of 1 atom acid united to 4 atoms water; or, when it is composed of

Acid .	6·25	or	100	or	58·1395
Water .	4·5	-	72.	-	41·8605
					100

We see, too, that the specific gravity of acid, containing only 1 atom water, is nearly the same with that containing 7 atoms water; or the two following compounds

1.	Acid	6·25	or	100	or	84·7457
	Water	1·125	-	18	-	15·2543

2.	Acid	6·25	or	100	or	44·2477
	Water	7·875	-	126	-	55·7523

have nearly the same specific gravity. It is obvious from this, that the specific gravity of an acetic acid does not assist us in determining its strength, or the true quantity of acid which it contains.

The following Table, from the Pharm. Central Blatt für 1839, drawn up by M. Mohr, exhibits the specific gravity of pure acetic acid of almost every strength :—

Per cent. of Glacial Acid (C. 4, H. 3, O. 3+Aq.)	Sp. Gr.	Per cent. of Glacial Acid. (C. 4, H. 3, O. 3+Aq.)	Sp. Gr.	Per cent. of Glacial Acid, (C. 4, H. 3, O. 3+Aq.)	Sp. Gr.
100	1·0635	66	1·069	32	1·0424
99	1·0635	65	1·068	31	1·041
98	1·067	64	1·068	30	1·040
97	1·0680	63	1·068	29	1·039
96	1·069	62	1·067	28	1·038
95	1·070	61	1·067	27	1·036
94	1·0706	60	1·067	26	1·035
93	1·0708	59	1·066	25	1·034
92	1·0716	58	1·066	24	1·033
91	1·0721	57	1·065	23	1·032
90	1·0730	56	1·064	22	1·031
89	1·0730	55	1·064	21	1·029
88	1·0730	54	1·063	20	1·027
87	1·0730	53	1·063	19	1·026
86	1.0730	52	1·062	18	1·025
85	1·0730	51	1·061	17	1·024
84	1·0730	50	1·060	16	1·023
83	1·0730	49	1·059	15	1·022
82	1·0730	48	1·058	14	1·020
81	1·0732	47	1·056	13	1·018
80	1·0735	46	1·055	12	1·017
79	1·0732	45	1·055	11	1·016
78	1·0732	44	1·054	10	1·015
77	1·073	43	1·053	9	1·013
76	1·072	42	1·052	8	1·012
75	1·072	41	1·0515	7	1·010
74	1·072	40	1·0513	6	1·008
73	1·071	39	1·050	5	1·0067
72	1·071	38	1·049	4	1·0065
71	1·071	37	1·048	3	1·004
70	1·070	36	1·047	2	1·002
69	1·070	35	1·046	1	1·001
68	1·070	34	1·045	0	1·0000
67	1·069	33	1·044		

C.

CHLORIC ACID.—This acid consists of 1 equivalent prime of chlorine=3·476,=5 of oxygen,+40·065; of which the sum 75·535 is the prime equivalent of the acid.

CHROMIC ACID is found in nature in combination with lead, and may be extracted by boiling the powdered mineral with twice its weight of carbonate of potash, and afterwards saturating the alkali by a mineral acid. It is of a red color, and may be obtained, from its solution, in ruby-colored crystals.* It has a sour metallic taste. When exposed to heat it gives off oxygen, and is converted into the protoxide. It is probably constituted of

1 equivalent of chromium	. .	28
3 do oxygen	. . .	24
		52

Various methods have been proposed for preparing this acid; the following furnished us by Mr. Robert Harrington, is probably the most simple:—

Take 100 measures of a cold saturated solution of bichromate of potash (prepared by boiling, and then allowing the solution to cool and deposit the excess of the salt,) and add to this from 120 to 150 measures of concentrated sulphuric acid; the latter should be free from sulphate of lead; as otherwise it would fall as chromate and sulphate of lead with the chromic acid on dilution with the bichromate. The mixture is then allowed to cool, and the chromic acid gradually crystalizes in beautiful dark crimson needles. Decant the fluid part, and place the crystals with the adhering sulphuric acid on a thick flat tile of biscuit porcelain; another tile is then to be placed upon the crystals and the whole submitted to a pressure for a considerable time. On removing the chromic acid it will be found in a perfectly dry state, and yielding a mere trace of sulphuric acid on examination.

Chromic acid may also be prepared from the chromate of lead, which results from the mixture of a salt of lead and bichromate of potash at the bottom of the *chrome tubs* used in dyeing yellows.† Two parts of strong sulphuric acid being

* It gives its color to the ruby.

† See chapters IV. and VI. Part III.

added to one part of dry chromate of lead slightly heated, and allowed to stand for about twelve hours; water is then added, when the lead is precipitated as a sulphate, and the chromic acid mixed with a little sulphuric acid remains in solution. The liquid is decanted and evaporated at a boiling heat; on cooling, the greater portion of the chromic acid separates in beautiful carmine-red crystals. If the process be carefully conducted, a great portion of what is now little better than thrown away, might be made useful by a trifling addition of expense.

We extract the following method of preparing chromic acid, by Mr. Maus, from a recent number of the *Annalen der Phyk*:—

A concentrated hot solution of the acid chromate of potash of commerce is decomposed, by means of fluo-silicic acid. The liquid is filtered and evaporated to dryness. The acid thus dried is dissolved in as small a quantity of water as possible, and when the solution has become clear, it is decanted from the gravelly deposit, formed by a slight quantity of fluo-silicate of potash, which had passed through the filter in the state of solution. It is necessary to avoid filtering the chromic acid thus dissolved, for it attacks the paper in the same manner as sulphuric acid does, and is converted into oxidule of chromium.

To prepare the fluo-silicic acid, the author uses a very large retort, with a long beak, into which he introduces the mixture of fluor-spar and glass. He pours in at once all the sulphuric acid necessary, namely, at most three parts acid for one part of spar; he shakes the vessel well, and directs the beak into a large long-necked balloon, in which he has previously poured a sufficient quantity of water, which he has shaken about in order to moisten the inside. The gas passing into it, falls in the form of dew upon the liquid surface, and that which is not absorbed at once by the water in the bottom, is attracted by the moisture of the wetted inside surface. Not the smallest trace of gas escapes, before the inner surface, as well as the surface of the water, are covered with a thick crust of silica. Then it is sufficient to shake the bal-

loon in order to moisten the inside again, and renew the surface of the liquid. In this way the water may be completely saturated with the acid, and it is easily freed from the crusts of silica, which fall to the bottom.

Chromic acid combines with the different bases, and forms a series of important salts. With potash it combines in two proportions, forming what is termed the yellow and the red chromate of potash. The yellow chromate of potash may be prepared by adding to 2 lbs. of red chromate one pound of caustic potash; it crystalizes in small crystals of a rich deep lemon color, composed of one proportion of acid with one of potash. This salt is not much used in the arts.

CITRIC ACID, in somewhat crude crystals, is employed with much advantage in calico-printing. Though the taste of this acid in crystals is as intensely acid as that of tartaric or even oxalic acid, yet it acts with less energy upon other bodies, and does not so easily decompose other salts as these two acids do. Thus, when we mix oxalate of ammonia with a solution of muriate of lime, oxalate or tartrate of lime immediately precipitates.

Scheele first procured this acid in its pure state from lemon juice, by the following process:—The juice put into a large tub, is to be saturated with dry chalk in fine powder, noting carefully the quantity employed. The citrate of lime which precipitates, being freed from the supernatant foul liquor, is to be well washed with repeated affusion and decantation of water. For every ten pounds of chalk employed, nine and a half pounds of sulphuric acid, diluted with six times its weight of water, are to be poured while warm upon the citrate of lime, and well mixed with it. At the end of twelve hours, or even sooner, the citrate will be all decomposed, dilute citric acid will float above, and sulphate of lime will be found at the bottom. The acid being drawn off, the calcareous sulphate must be thrown on a canvass filter, drained, and then washed with water to abstract the whole acid.

The citric acid thus obtained may be evaporated in leaden pans, over a naked fire, till it acquires the specific gravity 1·13; after which it must be transferred into another vessel,

evaporated by a steam or water bath till it assumes a syrupy aspect, when a pellicle appears first in patches and then over the whole surface. This point must be watched with great circumspection, for if it be passed, the whole acid runs a risk of being spoiled by carbonization. The steam or hot water must be instantly withdrawn, and the concentrated acid put into a crystalizing vessel in a dry, but not very cold apartment. At the end of four days, the crystalization will be complete. The crystals must be drained, re-dissolved in a small portion of water, the solution set aside to settle its impurities, then decanted, re-evaporated, and re-crystalized. A third or fourth crystalization may be necessary to obtain a colorless acid.

If any citrate of lime be left undecomposed by the sulphuric acid, it will dissolve in the citric acid, and obstruct its crystalization, and hence it will be safer to use the slightest excess of sulphuric acid, than to leave any citrate undecomposed. There should not, however, be any great excess of sulphuric acid. If there be, it is easily detected by nitrate of barytes, but not by the acetate of lead as prescribed by some chemical authors; *because the citrate of lead is not very soluble in the nitric acid*, and might thus be confounded with the sulphate, whereas citrate of barytes is perfectly soluble in that test acid. Sometimes a little nitric acid is added with advantage to the solution of the colored crystals, with the effect of whitening them.

The crystals of citric acid are oblique prisms with four faces, terminated by dihedral summits, inclined at acute angles. Their specific gravity is 1·617. They are unalterable in the air. When heated, they melt in their water of crystalization; and at a higher heat, they are decomposed.*

* Berzelius decomposed citric acid by mixing 1 part of citrate of lead with chlorate of potash, burning the mixture in a glass tube, and collecting the products. He deduced from this analysis that the constituents of citric acid per cent. are

Hydrogen . .	3·800
Carbon . .	41·369
Oxygen . .	54·831
	100

They contain eighteen per cent. of water, of which one-half may be separated in a dry atmosphere, at about 100° F., when the crystals fall into a white powder.*

If citric acid is adulterated with tartaric acid, the fraud may be detected by adding potash to the solution of the acid, which will occasion a precipitate of cream of tartar.

M.

MALIC ACID exists in the juices of many fruits and plants, alone, or associated with the citric, tartaric, and oxalic acids; and occasionally combined with potash or lime. Unripe apples, sloes, barberries, the berries of the mountain ash, elder berries, currants, gooseberries, strawberries, raspberries, bilberries, brambleberries, whortleberries, cherries, ananas, afford malic acid; the house-leek and purslane contain the malate of lime.

The acid may be obtained most conveniently from the juice of the berries of the mountain ash, or barberries. This must be clarified, by mixing with white of egg, and heating the mixture to ebullition; then filtering, digesting the clear liquor with carbonate of lead, till it becomes neutral; and evaporating the saline solution, till crystals of malate of lead be obtained. These are to be washed with cold water, and purified by re-crystalization. On dissolving the white salt in water, and passing a stream of sulphureted hydrogen through the solution, the lead will be all separated in the form of a sulphuret, and the liquor, after filtration and evaporation, will yield yellow granular crystals, or cauliflower concretions, of malic acid, which may be blanched by re-dissolution and digestion with bone-black, and re-crystalization.

Malic acid has no smell, but a very sour taste, deliquesces by absorption of moisture from the air, is soluble in alcohol, fuses at 150° Fahr., is decomposed at a heat of 348°, and

* Citric a[illegible] in crystals is composed, according to Dr. Ure's analysis, of carbon 35·[illegible] [illegible]xygen 59·7, and hydrogen 4·5; results which differ very little from those of [illegible]r. Prout, subsequently obtained. He also found its atomic weight to be 8·375, compared to oxygen 1·000.

affords by distillation a peculiar acid, the pyromalic. It consists in 100 parts, of 41·47 carbon; 3·51 hydrogen; and 55·02 oxygen; having nearly the same composition as citric acid.*

Mr. Everett has lately proposed the juice of the leaf-stalks of garden rhubarb as a source of malic acid. One imperial gallon of this juice contains 11,139¼ grs. of dry malic acid. The stalks should be peeled before pressing out the juice, as the cuticle contains much color. 20,000 grs. of the peeled stalks yield 12,500 grs. of juice. Mr. Everett's process is as follows:—neutralize with hydrate of lime, boil, filter, precipitate with nitrate of lead, allow it to stand for a few hours, boil, cool, filter, decompose the precipitate with sulphuric acid, avoiding excess, throw down the excess of lead from the supernatant portion with sulphureted hydrogen, evaporate, and crystalize.

M. Guerin observes, that Scheele obtained a peculiar acid, which he called malic acid, by the action of nitric acid upon mucilage. Tourcroy and Vanquelin repeated these experiments, and described a new uncrystalizable acid, which they considered as identical with the malic acid of fruits, this acid not having then been obtained in a crystaline state.

In order to prepare this artificial malic acid, M. Guerin employed the following process: one part of gum arabic was treated with two parts of nitric acid, diluted with half their weight of water; the mixture was heated moderately, until all the gum was dissolved, and the solution was then slowly boiled for two hours. After dilution with water, it was neutralized with ammonia; muriate of lime was then added, to precipitate the oxalic acid formed, and the whole was thrown on a filter; the filtered liquor was yellowish red, and the solution of nitrate of lead was added to it; a yellowish precipitate was obtained, which, after being well washed, was decomposed by a current of sulphureted hydrogen gas, and the acid liquor was evaporated with a gentle heat; this was again saturated with ammonia, and decomposed by nitrate

* A crude malic acid might be economically extracted from the fruit of the mountain ash, applicable to many purposes; but it has not been hitherto manufactured upon the great scale.

of lead; and the precipitate decomposed by sulphureted hydrogen, gave an acid liquor, which, though evaporated to the consistence of a syrup, gave no crystals.*

The properties of this acid are, that it is slightly yellow, reddens litmus, its taste resembles that of malic acid, is inodorous, and more dense than water. It is very soluble, both in water and in alcohol; it causes precipitation in lime, barytes, strontia water, which is re-dissolved by excess of acid. The salts of lead give a bulky precipitate with it, which is insoluble in cold water, and in excess of the acid; boiling water dissolves a small portion, which crystalizes as the solution cools. When this acid is neutralized by ammonia, and heated, an acid is formed, which crystalizes in colorless prisms with a rectangular base. Its taste is slightly acid; cold water dissolves it sparingly, but boiling water readily. It is insoluble in alcohol. This acid may be obtained by treating one part of sugar or of starch with half a part of nitric acid, in the same manner as already described with gum.

MURIATIC or HYDROCHLORIC ACID; anciently *marine acid*, and *spirit of salt*. The knowledge of the composition of muriatic acid and the theory of chlorides, for which we are indebted to Sir H. Davy, constitutes one of the greatest improvements of modern chemistry. It was only advanced by its great discoverer in general terms. Dr. John Davy afterwards published a most admirable paper on the chlorides, containing a very great number of experiments, the exactness of which Dr. Thomson proved, from having repeated almost the whole of them.†

This acid is extracted from sea-salt, by the action of sulphuric acid and a moderate heat. The acid gas which exhales, is rapidly condensed by water. 100 cubic inches of water are capable of absorbing no less than 48,000 cubic inches of the acid gas, whereby the liquid acquires a specific gravity of 1·2109; and a volume of 142 cubic inches. This vast condensation is accompanied with a great production

* *Ann. de Chim. et de Phys.*, tom. xlix. p. 274. † Phil. Trans. 1823.

of heat, whence it becomes necessary to apply artificial refrigeration, especially if so strong an acid as the above is to be prepared. In general, the muriatic acid of commerce has a specific gravity varying from 1·15 to 1·20; and contains, for the most part, considerably less than 40 parts by weight of acid gas in the hundred. The above stronger acid contains 42·68 per cent. by weight; for since a cubic inch of water, which weighs 252·5 grains, has absorbed 480 cubic inches = 188 grains of gas; and 252·5+188 = 440·5; then 440·5 : 188 : : 100 : 42·68. In general a very good approximation may be found to the percentage of real muriatic acid, in any liquid sample, by multiplying the decimal figures of the specific gravity by 200. Thus for example, at 1·162 we shall have by this rule 0·162+200 = 32·4, for the quantity of gas in 100 parts of the liquid. Muriatic acid gas consists of chlorine and hydrogen combined, without condensation, in equal volumes. Its specific gravity is 1·247, air = 1·000.

By sealing up muriate of ammonia and sulphuric acid, apart, in a strong glass tube recurved, and then causing them to act on each other, Sir H. Davy procured liquid muriatic acid. He justly observes, that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependent on the application of cold, whether natural or artificial; for as gases diminish only $\frac{1}{480}$ in volume for every degree of Fahrenheit's scale beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature; and when attempts are made to condense gases into liquids by sudden mechanical compression, the heat instantly generated presents a formidable obstacle to the success of the experiment; whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it

may easily be assisted by artificial cold, in cases where gases approach near to that point of compression and temperature at which they become vapors.

The muriatic acid of commerce has usually a yellowish tinge, but when chemically pure, it is colorless. It fumes strongly in the air, emitting a corrosive vapor of a peculiar smell. The characteristic test of muriatic acid in the most dilute state, is nitrate of silver, which causes a curdy precipitate of chloride of silver.

The preparation of this acid upon the great scale is frequently effected by acting upon sea-salt in hemispherical iron pots, or in cast-iron cylinders, with concentrated sulphuric acid; taking 6 parts of the salt to 5 of the acid. The mouth of the pot may be covered with a slab of silicious freestone, perforated with two holes of about two inches diameter each, into the one of which the acid is poured by a funnel in successive portions, and into the other, a bent glass, or stone-ware tube, is fixed, for conducting the disengaged muriatic gas into a series of large globes of bottle glass, one third filled with water, and laid on a sloping sand-bed. A week is commonly employed for working off each pot; no heat being applied to it till the second day.

The decomposition of sea-salt by sulphuric acid, was at one time carried on by some French manufacturers in large leaden pans, 10 feet long, 5 feet broad, and a foot deep, covered with sheets of lead, and luted. The disengaged acid gas was made to circulate in a conduit of glazed bricks, nearly 650 yards long, where it was condensed by a sheet of water exceedingly thin, which flowed slowly in the opposite direction of the gas down a slope of 1 in 200. At the end of this canal nearest the apparatus, the muriatic acid was as strong as possible, and pretty pure; but towards the other end, the water was hardly acidulous. The condensing part of this apparatus was therefore tolerably complete; but as the decomposition of the salt could not be finished in the leaden pans, the acid mixture had to be drawn out of them, in order to be completely decomposed in a reverberatory furnace; in this way nearly 50 per cent. of the muriatic acid

was lost. And besides, the great quantity of gas given off during the emptying of the lead-chambers was apt to suffocate the workmen, or seriously injured their lungs, causing severe hemoptysis. The employment of muriatic acid is so inconsiderable, and the loss of it incurred in the preceding process is of so little consequence, that subsequently both in France and in England, sulphate of soda, for the soda manufacture, has been procured with the dissipation of the muriatic acid in the air. In the method more lately resorted to, the gaseous products are discharged into extensive vaults, where currents of water condense them and carry them off into the river. The surrounding vegetation is thereby saved in some measure from being burned up, an accident which was previously sure to happen when fogs precipitated the floating gases upon the ground. At Newcastle, Liverpool, and Marseilles, where the consumption of muriatic acid bears no proportion to the manufacture of soda, this process is now practised upon a vast scale, to extract the sulphate of soda, and to recommence another operation. This sulphate ought to be white and uniform, exhibiting in its fracture no undecomposed sea-salt.*

Liquid muriatic acid has a very sour corrosive taste, a pungent suffocating smell, and acts very powerfully upon a vast number of mineral, vegetable, and animal substances. It is much employed for making many metallic solutions; and in combination with nitric acid, it forms the aqua regia of the alchemists, so called from its property of dissolving gold.—(See *Nitro-Muriatic Acid.*)

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* *Sulphate of soda* crystalizes commonly in flat four-sided prisms, the faces of which are channelled longitudinally. It effloresces very speedily when exposed to the air; and loses all its water of crystalization in 24 hours, when confined in the exhausted receiver of an air pump, with sulphuric acid. Its constituents are

1 atom sulphuric acid	5
1 atom soda	4
10 atoms water	11·25
	20·25

There is usually a minute quantity of water lodged mechanically between the plates of the crystals. This, in an integrant particle of the salt, may amount at a maximum to 0·03 parts, which constitutes about $\frac{1}{57}$th part of the water in the salt.

Table of Muriatic Acid, by Dr. Ure.

Acid of 120 in 100	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 120 in 100	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 120 in 100	Specific Gravity.	Chlorine.	Muriatic Gas.
100	1·2000	39·675	40·777	66	1·1328	26·186	26·913	32	1·0637	12·697	13·049
99	1·1982	39·278	40·369	65	1·1308	25·789	26·505	31	1·0617	12·300	12·641
98	1·1964	38·882	39·961	64	1·1287	25·392	26·098	30	1·0597	11·903	12·233
97	1·1946	38·485	39·554	63	1·1267	24·996	25·690	29	1·0577	11·506	11·825
96	1·1928	38·089	39·146	62	1·1247	24·599	25·282	28	1·0557	11·109	11·418
95	1·1910	37·692	38·738	61	1·1226	24·202	24·874	27	1·0537	10·712	11·010
94	1·1893	37·296	38·330	60	1·1206	23·805	24·466	26	1·0517	10·316	10·602
93	1·1875	36·900	37·923	59	1·1185	23·408	24·058	25	1.0497	9·919	10·194
92	1·1857	36·503	37·516	58	1·1164	23·012	23·050	24	1·0477	9·522	9·786
91	1·1846	36·107	37·108	57	1·1143	22·615	23·242	23	1·0457	9·126	9·379
90	1·1822	35·707	36·700	56	1·1123	22·218	22·834	22	1·0437	8·729	8·971
89	1·1802	35·310	36 292	55	1·1102	21·822	22·426	21	1·0417	8·332	8·563
88	1·1782	34·913	35·884	54	1·1082	21·425	22·019	20	1·0397	7·935	8.155
87	1·1762	34·517	35·476	53	1·1061	21·028	21·611	19	1·0377	7·538	7·747
86	1·1741	34·121	35·068	52	1·1041	20·632	21·203	18	1·0357	7·141	7·340
85	1·1721	33·724	34·660	51	1·1020	20·235	20·796	17	1·0337	6·745	6·932
84	1·1701	33·328	34·252	50	1·1000	19·837	20·388	16	1·0318	6·348	6·524
83	1·1681	32·931	33·845	49	1·0980	19·440	19·980	15	1·0298	5·951	6·116
82	1·1661	32·535	33·437	48	1·0960	19·044	19·572	14	1·0279	5·554	5·709
81	1·1641	32·136	33·029	47	1·0939	18·647	19·165	13	1·0259	5·158	5·301
80	1·1620	31·746	32·621	46	1·0919	18·250	18·757	12	1·0239	4·762	4·893
79	1·1599	31·343	32·213	45	1·0899	17·854	18·349	11	1·0220	4·365	4·486
78	1·1578	30·946	31·805	44	1·0879	17·457	17·941	10	1·0200	3·968	4 078
77	1·1557	30·550	31·398	43	1·0859	17·060	17·534	9	1·0180	3·571	3·670
76	1·1536	30·153	30·990	42	1·0838	16·664	17·126	8	1·0160	3·174	3·262
75	1·1515	29·757	30·582	41	1·0818	16·267	16·718	7	1·0140	2·778	2·854
74	1·1494	29·361	30·174	40	1·0798	15·870	16·310	6	1·0120	2·381	2·447
73	1·1473	28·964	29·767	39	1.0778	15·474	15·902	5	1·0100	1·984	2·039
72	1·1452	28·567	29·359	38	1·0758	15·077	15·494	4	1·0080	1·588	1·631
71	1·1431	28·171	28·951	37	1·0738	14·680	15·087	3	1·0060	1·191	1·224
70	1·1410	27·772	28·544	36	1·0718	14·284	14·679	2	1·0040	0·795	0·816
69	1·1389	27·376	28·136	35	1·0697	13·887	14·271	1	1·0020	0·397	0·408
68	1·1369	26·979	27·728	34	1·0677	13·490	13·863				
67	1·1349	26·583	27·321	33	1·0657	13·094	13·456				

N.

NITRIC ACID (Aquafortis) is also of very great importance in the arts, especially in dyeing and calico printing. It exists extensively in combination with the bases, potash, soda, lime, magnesia, in both the mineral and vegetable kingdoms. This acid is never found insulated. It was distilled from saltpetre so long ago as the thirteenth century, by igniting that salt, mixed with copperas or clay, in a retort. Nitric acid is generated when a mixture of oxygen and nitrogen gases, confined over water or an alkaline solution, has a series of electrical explosions passed through it. In this way the salu-

brious atmosphere may be converted into corrosive aquafortis. When a little hydrogen is introduced into the mixed gases, standing over water, the chemical agency of the electricity becomes more intense, and the acid is more rapidly formed from its elements, with the production of some nitrate of ammonia.

Nitric acid is usually made on the small scale by distilling, with the heat of a sand-bath, a mixture of three parts of pure nitre, and two parts of strong sulphuric acid, in a large glass retort, connected by a long glass tube with a globular receiver surrounded by cold water. By a well-regulated distillation, a pure acid, of specific gravity 1·500, may be thus obtained, amounting in weight to about two-thirds of the nitre employed. To obtain easily the whole nitric acid, equal weights of nitre and concentrated sulphuric acid may be taken; in which case but a moderate heat need be applied to the retort. The residuum will be bisulphate of potash. When only the single equivalent proportion of sulphuric acid is used, namely, 48 parts for 100 of nitre, a much higher heat is required to complete the distillation, whereby more or less of the nitric acid is decomposed, while a compact neutral sulphate of potash is left in the retort, very difficult to remove by solution in water, and therefore apt to destroy the vessel.

Aquafortis is manufactured upon the great scale in iron pots or cylinders of the same construction as described under muriatic acid. The more concentrated the sulphuric acid is, the less corrosively will it act upon the metal; and it is commonly used in the proportion of one part by weight to two of nitre. The salt being introduced into the cool retort, and the lid being luted tight, the acid is to be slowly poured in through the aperture; the aperture being connected by a long glass tube with a range of balloons inserted into each other, and laid upon a sloping bed of sand. A bottle, with three tubulures partly filled with water, which is required for condensing muriatic acid gas, must, for the present purpose, be replaced by a series of empty receivers, either of glass or salt-glazed stoneware. The cylinders should be only half filled, and be worked off by a gradually raised heat.

Commercial aquafortis is very generally contaminated with sulphuric and muriatic acids, as also with alkaline sulphates and muriates. The quantity of these salts may be readily ascertained by evaporating in a glass capsule a given weight of the aquafortis; while that of the muriatic acid may be determined by nitrate of silver; and of sulphuric acid, by nitrate of baryta. Aquafortis may be purified in a great measure, by re-distillation at a gentle heat; rejecting the first liquid which comes over, as it contains the chlorine impregnation; receiving the middle portion as genuine nitric acid; and leaving a residuum in the retort, as being contaminated with sulphuric acid.

Since nitrate of soda has been so abundantly imported into Europe from Peru, it has been employed by many manufacturers in preference to nitre for the extraction of nitric acid, because it is cheaper, and because the residuum of the distillation, being sulphate of soda, is more readily removed by solution from glass retorts, when a range of these set in a gallery furnace is the apparatus employed. Nitric acid of specific gravity 1·47 may be obtained colorless; but by further concentration a portion of it is decomposed whereby some nitrous acid is produced, which gives it a straw-yellow tinge. At this strength it exhales white or orange fumes, which have a peculiar, though not very disagreeable smell; and even when largely diluted with water, it tastes extremely sour.* The greatest density at which it can be obtained is 1·51 or perhaps 1·52, at 60° F., in which state, or even when much weaker, it powerfully corrodes all animal, vegetable, and most metallic bodies. When slightly diluted it is applied, with

* Nitric acid is a highly corrosive fluid, and acts as a powerful cautery when applied to the skin, which it stains of a permanent yellow. It is decomposed, with great violence, by most substances which have an affinity for oxygen; which element enters so largely into its composition. If it be brought into contact with hydrogen, at a high temperature, a violent detonation will be the consequence; but the experiment is dangerous, and should not be made without great caution. When poured upon warm dry charcoal, in powder, combustion ensues, with the emission of copious fumes of deutoxide of nitrogen. Spirits of turpentine may be inflamed by suddenly pouring nitric acid upon it: the acid should be poured out of a phial attached to a long stick, or there would be danger to the eyes of the operator.

many precautions, to silk and woolen stuffs, to stain them of a bright yellow hue.

In the dry state, as it exists in nitre, this acid consists of 26·15 parts by weight of azote, and 73·85 of oxygen; or of 2 volumes of the first gas, and 5 volumes of the second.

When of specific gravity 1·5, it boils at about 210° Fahr.; of 1·45, it boils at about 240°; of 1·42, it boils at 253°; and of 1·40, at 246° F. If an acid stronger than 1·420 be distilled in a retort, it gradually becomes weaker; and if weaker than 1·42, it gradually becomes stronger, till it assumes that standard density. Acid of specific gravity 1·485 has no more action upon tin than water has, though when either stronger or weaker it oxidizes it rapidly, and evolves fumes of nitrous gas with explosive violence.

In two papers, by Dr. Ure, upon nitric acid, published in the fourth and sixth volumes of the Journal of Science (1818 and 1819), he investigated the chemical relations of these phenomena, and obtained the following results:—Acid of 1·420 consists of 1 atom of dry acid, and 4 of water; acid of 1·485, of 1 atom of dry acid, and 2 of water; the latter compound possesses a stable equilibrium as to chemical agency; the former as to calorific. Acid of specific gravity 1·334, consisting of 7 atoms of water, and 1 of dry acid, resists the decomposing agency of light. Nitric acid acts with great energy upon most combustible substances, simple or compound, giving up oxygen to them, and resolving itself into nitrous gas,* or even azote.† Such is the result of its action upon hydrogen, phosphorus, sulphur, charcoal, sugar, gum, starch, silver, mercury, copper, iron, tin, and most other metals.

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* When nitric acid is quite free from nitrous gas, it is colorless, and nearly as limpid as water; but the presence of this gas gives it a yellow, a red, or a brown color, according to its quantity.

† It appears from an experiment, made by Dr. Thomson, that 8·65 grains of saltpetre contain 4·004 cubic inches of azotic gas. Now, as nitre is a compound of 6 potash and 6·75 nitric acid—and as nitric acid is a compound of 1·75 azote and 5 oxygen—it is obvious, that 8·65 grains of nitre contain

Azote	1·187254 gr. or	4·00386 cubic inches,
Oxygen	3·392155 . .	10·00960 cubic inches.
	4·579410	

A Table of Nitric Acid, by Dr. Ure.

Specific Gravity.	Liq. Acid in 100	Dry acid in 100.	Specific gravity.	Liq. Acid in 100	Dry acid in 100.	Specific gravity.	Liq. Acid in 100	Dry acid in 100.	Specific gravity.	Liq. Acid in 100	Dry acid in 100.
1·5000	100	79·700	1·4189	75	59·775	1·2947	50	39·850	1·1403	25	19·925
1·4980	99	78·903	1·4147	74	58·978	1·2887	49	39·053	1·1345	24	19·128
1·4960	98	78·106	1·4107	73	58·181	1·2826	48	38·256	1·1286	23	18·331
1·4940	97	77·309	1·4065	72	57·384	1·2765	47	37·459	1·1227	22	17·534
1·4910	96	76·512	1·4023	71	56·587	1·2705	46	36·662	1·1168	21	16·737
1·4880	95	75·715	1·3978	70	55·790	1·2644	45	35·865	1·1109	20	15·940
1·4850	94	74·918	1·3945	69	54·993	1·2583	44	35·068	1·1051	19	15·143
1·4820	93	74·121	1·3882	68	54·196	1·2523	43	34·271	1·0993	18	14·346
1·4790	92	73·324	1·3833	67	53·399	1·2462	42	33·474	1·0935	17	13·549
1·4760	91	72·527	1·3783	66	52·602	1·2402	41	32·677	1·0878	16	12·752
1·4730	90	71·730	1·3732	65	51·805	1·2341	40	31·880	1·0821	15	11·955
1·4700	89	70·933	1·3681	64	51·068	1·2277	39	31·083	1·0764	14	11·158
1·4670	88	70·136	1·3630	63	50·211	1·2212	38	30·286	1·0708	13	10·361
1·4640	87	69·339	1·3579	62	49·414	1·2148	37	29·489	1·0651	12	9·564
1·4600	86	68·542	1·3529	61	48·617	1·2084	36	28·692	1·0595	11	8·767
1·4570	85	67·745	1·3477	60	47·820	1·2019	35	27·895	1·0540	10	7·970
1·4530	84	66·948	1·3427	59	47·023	1·1958	34	27·098	1·0485	9	7·173
1·4500	83	66·155	1·3376	58	46·226	1·1895	33	26·301	1·0430	8	6·376
1·4460	82	65·354	1·3323	57	45·429	1·1833	32	25·504	1·0375	7	5·579
1·4424	81	64·557	1·3270	56	44·632	1·1770	31	24·707	1·0320	6	4·782
1·4385	80	63·760	1·3216	55	43·835	1·1709	30	23·900	1·0267	5	3·985
1·4346	79	62·963	1·3163	54	43·038	1·1648	29	23·113	1·0212	4	3·188
1·4306	78	62·166	1·3110	53	42·241	1·1587	28	22·316	1·0159	3	2·391
1·4269	77	61·369	1·3056	52	41·444	1·1526	27	21·519	1·0106	2	1·594
1·4228	76	60·572	1·3001	51	40·647	1·1465	26	20·722	1·0053	1	0·797

NITRO-MURIATIC ACID (*Aqua Regia*).—To this compound acid, the name *aqua regia* has been given, because it has the property of dissolving gold, which was called the king of metals. But it should be regarded as a mixture of muriatic acid and nitric acid, which combine their forces to effect solutions which they could not separately do. If strong nitric acid, orange colored by saturation with nitrous gas (deutoxyde of azote), be mixed with the strongest liquid muriatic acid, no other effect is produced than might be expected from the action of nitrous acid of the same strength upon an equal quantity of water; nor has the mixed acid so formed any power of acting upon gold or platina. But if colorless aqua fortis and ordinary muriatic acid be mixed together, the mixture immediately becomes yellow, and acquires the power of dissolving these two noble metals. When gently heated, pure chlorine gas rises from it, and its color becomes deeper; when further heated, chlorine still rises, but now mixed with nitrous acid gas. If the process has been very long con-

tinued, till the color becomes very dark, no more chlorine can be procured, and the liquor has lost the power of dissolving gold. It then consists of nitrous and muriatic acids. It appears, therefore, that aqua regia owes its peculiar properties to the mutual decomposition of the nitric and muriatic acids; and that water, chlorine, and nitrous acid gas are the results of that reaction. Aqua regia does not, strictly speaking, oxidize gold and platinum; it causes merely their combination with chlorine.

Nitro-muriatic acid may be prepared, either by simple mixture of the nitric and muriatic acids, or by dissolving muriate of ammonia or of soda in nitric acid. Other salts might be made use of, for example nitre (nitrate of potash), which might be dissolved in muriatic acid.

O.

OXALIC ACID.—This is one of the most important of all the combustible acids as far as chemical analysis is concerned.* It is usually prepared upon the small scale by digesting four parts of nitric acid of specific gravity 1·4, upon one part of sugar, in a glass retort; but on the large scale, in a series of salt-glazed stoneware pipkins, two-thirds filled, and set in a water bath. The addition of a little sulphuric acid has been found to increase the product. 15 pounds of sugar yield fully 17 pounds of the crystaline acid. This acid exists in the juice of wood sorrel, the *oxalis acetosella*, in the state of a bioxalate; from which the salt is extracted as an object of commerce in Switzerland, and sold under the name of salt of sorrel, or sometimes, most incorrectly, under that of salt of lemons.

Some prefer to make oxalic acid by acting upon 4 parts of sugar, with 24 parts of nitric acid of specific gravity 1·220, heating the solution in a retort till the acid begins to decom-

* Oxalic acid is employed chiefly for certain styles of discharge in calico-printing, and for whitening the leather of boot-tops. It is also used in scouring operations.—(See chapter IV. Part V.)

pose, and keeping it at this temperature as long as nitrous gas is disengaged. The sugar loses a portion of its carbon, which, combining with the oxygen of the nitric acid, becomes carbonic acid, and escapes along with the deutoxide of nitrogen. The remaining carbon and hydrogen of the sugar being oxidized at the expense of the nitric acid, generate a mixture of two acids, the oxalic and the malic. Whenever gas ceases to issue, the retort must be removed from the source of heat, and set aside to cool; the oxalic acid crystalizes, but the malic remains dissolved. After draining these crystals upon a filter funnel, if the brownish liquid be further evaporated, it will furnish another crop of them. The residuary mother water is generally regarded as malic acid, but it also contains both oxalic and nitric acids; and if heated with 6 parts of the latter acid, it will yield a good deal more oxalic acid at the expense of the malic. The brown crystals now formed being, however, penetrated with nitric, as well as malic acid, must be allowed to dry and effloresce in warm dry air, whereby the nitric acid will be got rid of without injury to the oxalic. A second crystalization and efflorescence will entirely dissipate the remainder of the nitric acid, so as to afford pure oxalic acid at the third crystalization. Sugar affords, with nitric acid, a purer oxalic acid, but in smaller quantity, than saw-dust, glue, silk, hairs, and several other animal and vegetable substances.

Oxalic acid occurs in aggregated prisms when it crystalizes rapidly, but in tables of greater or less thickness when slowly formed. They lose their water of crystalization in the open air, fall into powder, and weigh 0·28 less than before; but still retain 0·14 parts of water, which the acid does not part with except in favor of another oxide, as when it is combined with oxide of lead. The effloresced acid contains 20 per cent. of water, according to Berzelius. By an analysis made by Dr. Ure, the crystals consist of three prime equivalents, of water = 27, combined with one of dry oxalic acid = 36; or in 100 parts, of 42·86 of water with 57·14 of acid. The acid itself consists of 2 atoms of carbon = 12, + 3 of oxygen = 24; of which the sum is, as above stated, 36.

This acid has a sharp sour taste, and sets the teeth on edge; half a pint of water, containing only 1 gr. of acid, very sensibly reddens litmus paper. Nine parts of water dissolve one part of the crystals at 60° F., and form a solution, of spec. grav. 1·045, which when swallowed acts as a deadly poison. Alcohol also dissolves this acid. It differs from all the other acid products of the vegetable kingdom, in containing no hydrogen, which fact has been demonstrated (by Berzelius) by its giving out no muriatic acid gas, when heated in a glass tube with calomel or corrosive sublimate.*

The apparent figure of the crystals of oxalic acid is a flat four-sided prism; but Mr. Brooke informs us that the primary form is an oblique rhombic prism. The rhombic base, to the unexperienced eye, passes for one of the sides of the flat prism; and as the crystal is usually attached by one of its sides, two of the lateral faces appear to the eye as the dihedral summit. Two of the opposite lateral edges are usually deeply truncated, which makes the prism six-sided instead of four-sided.† These crystals being always in the same state, it is of importance to know with precision the weight of them capable of neutralizing an atom of each of the bases. The following experiments were made by Dr. Thomson, to determine this point:—

Nine grains of crystals of oxalic acid were dissolved in distilled water, neutralized by ammonia, and evaporated to dryness by a very gentle heat, in order to get rid of all excess of ammonia. The oxalate of ammonia, thus formed, was redissolved in water.

6·25 grains of pure calcareous spar were dissolved in very dilute muriatic acid; the solution was slowly evaporated to dryness, twice successively, in order to drive off any excess of acid which might have been present; and the muriate of lime, thus rendered neutral, was redissolved in water.

These two solutions being mixed together, a double decomposition took place, and the insoluble oxalate of lime gradu-

* Ann. de Chim. et de Phys. xviii. 155.

† Annals of Philosophy, (second series) VI. 119.

ally precipitated to the bottom, leaving a clear and transparent liquor, containing in solution the muriate of ammonia formed by the mutual decomposition of the two salts. This liquid, being tested by oxalate of ammonia and by muriate of lime, was not affected by either of these reagents, showing that it contained no sensible quantity either of lime or of oxalic acid.

Oxalate of ammonia is an excellent reagent for detecting lime and its salts in any solution. The acid itself, or the bi-oxalate of potash, is often used for removing ink or iron-mould stains from linen.—(See chapter IV., Part V.)

Dr. Turner having lately examined the volatility of oxalic acid, finds the substance to rise at temperature so low as 212° without undergoing any chemical change, except that the common crystals lose two-thirds or two equivalents of their water of crystalization. If ordinary oxalic acid be placed in a water bath, and heated, it effloresces, losing nearly the proportion of water mentioned; if exposed to the cold air, it recovers the water; but if continued hot, it sublimes, and minute acicular crystals form on the surface. If purified oxalic acid in crystals be exposed to 350° or 400°, in a deep evaporating basin, and when sublimation begins, the vessel be covered by a layer of smooth filtering paper, a fold of blotting paper, and a larger evaporating basin containing cold water, the oxalic acid condenses in crystals on the filtering paper, or falls on the side of the dish, and after an hour may be removed, and quickly secured in a stoppered bottle. Thus sublimed, the acid is in minute shining acicular crystals, which, on exposure to air, become dull, and regain the two equivalents of water.

At higher temperatures the sublimation proceeds more rapidly. At 300° or 330°, none is decomposed. At 360° or 400°, the sublimation is very free; at 414° it fuses, and boils freely; above 330°, decomposition to a greater or smaller extent occurs, and is indicated by the appearance of water. By combining the sublimed acid with bases, &c. &c. its unchanged nature was ascertained.

Dr. Turner found that a saturated solution of oxalic acid

at the temperature of 50°, contained 1 part crystalized acid, and 1.55 parts water. At 57°, 9.5 parts of water dissolved 1 part of crystalized acid. At 212°, the quantity of acid dissolved is almost unlimited; at 220° the crystals fuse in the water of crystalization.

P.

PYROLIGNEOUS ACID (or *Wood Vinegar*).—The process for making this acid is founded upon the general property of heat, to separate the elements of vegetable substances, and to unite them anew in another order, with the production of compounds which did not exist in the bodies subjected to its action. The respective proportion of these products varies, not only in the different substances, but also in the same substance, according as the degree of heat has been greater or less, or conducted with more or less skill. When we distill a vegetable body in a close vessel, we obtain at first the included water, or that of vegetation; there is next formed another portion of water, at the expense of the oxygen and hydrogen of the body; a proportional quantity of charcoal is set free, and, with the successive increase of the heat, a small portion of charcoal combines with the oxygen and hydrogen to form acetic acid. This was considered, for some time, as a peculiar acid, and was accordingly called *pyroligneous* acid. As the proportion of carbon becomes preponderant, it combines with the other principles, and then some empyreumatic oil is volatilized, of little color, but which becomes thicker, and of a darker tint, always getting more loaded with carbon.

In an establishment near Manchester, where this acid is manufactured on a large scale, the retorts are of cast-iron, 6 feet long, and 3 feet 8 inches in diameter. Two of these cylinders are heated by one fire, the flame of which plays round their sides and upper surface; but the bottom is shielded by fire-tiles from the direct action of the fire. 2 cwts. of coals are sufficient to complete the distillation of one charge of wood; 36 imperial gallons of crude vinegar,

of specific gravity 1·025, being obtained from each retort. The process occupies 24 hours. The retort-mouth is then removed, and the ignited charcoal is raked out for extinction into an iron chest, having a groove round its edges, into which a lid is fitted.

When this pyroligneous acid is saturated with quicklime, and distilled, it yields one per cent. of pyroxilic spirit (sometimes called naptha); which is rectified by two or three successive distillations with quicklime.

The tarry deposite of the crude pyroligneous acid, being subjected to distillation by itself, affords a crude pyro-acetic ether, which may also be purified by re-distillation with quicklime, and subsequent agitation with water.

The pyrolignite of *lime* is made by boiling the pyroligneous acid in a large copper, which has a sloping spout at its lip, by which the tarry scum freely flows over, as it froths up with the heat. The fluid compound thus purified is syphoned off into another copper, and mixed with a quantity of alum equivalent to its strength, in order to form the red liquor, or acetate of alumina, *of the calico printer*. The acetate of lime, and sulphate of alumina and potash, mutually decompose each other; with the formation of sulphate of lime, which falls immediately to the bottom.

M. Kestner, of Thann, in Alsace, obtains, in his manufactory of pyroligneous acid, 5 hectolitres (112 gallons imperial, nearly) from a cord containing 93 cubic feet of wood. The acid is very brown, much loaded with tar, and marks 5° Baumé; 220 kilogrammes of charcoal are left in the cylinders; 500 litres of that brown acid produce, after several distillations, 375 of the pyroligneous acid of commerce, containing 7 per cent. of acid, with a residuum of 40 kilogrammes of pitch. For the purpose of making a crude acetate of lead (pyrolignite) he dries pyrolignite of lime upon iron plates, mixes it with the equivalent decomposing quantity of sulphuric acid, previously diluted with its own weight of water, and cooled; and transfers the mixture as quickly as possible into a cast-iron cylindric still, built horizontally in a furnace; the under half of the mouth of the

cylinder being always cast with a semicircle of iron. The acetic acid is received into large salt-glazed stone bottles. From 100 parts of acetate of lime, he obtains 133 of acetic acid, at 38° Baumé. It contains always a little sulphurous acid from the reaction of the tar and the sulphuric acid.

S.

SULPHURIC ACID (Vitriolic Acid, or Oil of Vitriol).—This acid has been known ever since the seventh century,* and of all the acids is most extensively used in the arts, and is, in fact, the primary agent for obtaining almost all the others, by disengaging them from their saline combinations. In this way, nitric, muriatic, tartaric, acetic, and many other acids, are procured. It is employed in the direct formation of alum, of the sulphates of copper, zinc, potassa, soda; in that of sulphuric ether, of sugar by the saccharification of starch, and in the preparation of phosphorus, &c. It serves also for opening the pores of skins in tanning, for clearing the surfaces of metals, for determining the nature of several salts by the acid characters that are disengaged, &c.

There are several ways of procuring this acid, but we shall only give the most approved methods, as practised in the best chemical works. This acid was formerly procured by the distillation of dried sulphate of iron, called *green* vitriol, whence the corrosive liquid which came over, having an oily consistence, was denominated oil of vitriol. This method has been superseded in Great Britain, France, and most other countries, by the combustion of sulphur along with nitre, in large leaden chambers.

The production of sulphuric acid from sulphur and nitre may be elegantly illustrated by means of a glass globe with a stoppered hole at its side, and four bent glass tubes inserted into a leaden cap in its upper orifice. The first tube is to be connected with a heated matrass, disengaging sulphurous

* Mention is often made of *Vinegar* in the Old Testament.

acid from copper filings and sulphuric acid; the second with a retort, disengaging more slowly deutoxide of azote (nitric oxide) from copper filings and nitric acid; the third with a vessel for furnishing steam in a moderate current towards the end of the process, when no water has been previously admitted into the balloon; the fourth tube may be upright, and terminate in a small funnel. Through the opening in the side of the globe, atmospherical air is to be admitted from time to time, by removing the stopper; after which, the residuary lighter azote may be allowed to escape by the funnel orifice.

M. M. Clement and Desormes have shown that nitrous acid gas and sulphurous acid gas mixed, react on each other through the intervention of moisture; that there resulted thence a combination of sulphuric acid, deutoxide of azote (nitrous gas), and water; that this crystaline compound was instantly destroyed by more water, with the separation of the sulphuric acid in a liquid state, and the disengagement of nitrous gas; that this gas re-constituted nitrous acid at the expense of the atmospheric oxygen of the leaden chamber, and thus brought matters to their primary condition. From this point, starting again, the particles of sulphur in the sulphurous acid, through the agency of water, became fully oxygenated by the nitrous acid, and fell down in heavy drops of sulphuric acid, while the nitrous gas derived from the nitrous acid, had again recourse to the air for its lost dose of oxygen. This beautiful interchange of the oxygenous principle was found to go on, in their experiments, till either the sulphurous acid, or oxygen in the air, was exhausted.

They verified this proposition, with regard to what occurs in sulphuric acid chambers, by mixing in a crystal globe the three substances, deutoxide of azote, sulphurous acid, and atmospheric air. The immediate production of red vapors indicated the transformation of the deutoxide into nitrous acid gas; and now the introduction of a very little water caused the proper *reaction*, for opaque vapors rose, which deposited white star-form crystals on the surface of the glass.

The gases were once more transparent and colorless; but another addition of water melted these crystals with effervescence, when ruddy vapors appeared. In this manner the phenomena were made to alternate, till the oxygen of the included air was expended, or all the sulphurous acid was converted into sulphuric. The residuary gases were found to be nitrous acid gas and azote, without sulphurous acid gas; while unctuous sulphuric acid bedewed the inner surface of the globe. Hence they justly concluded their new theory of the manufacture of oil of vitriol to be demonstrated. In consequence of their discovery, the manufacture of this acid has received such improvements, that a nearly double product of it may now be obtained from the same weight of materials. Indeed, the economy may be reckoned to be much greater; for one half of the more costly ingredient, the nitre, formerly employed with a given weight of sulphur, suffices at present.

M. Clement demonstrated the proposition relative to the influence of temperature by a decisive experiment. He took a glass globe, furnished with three tubulures, and put a bit of ice into it. Through the first opening he then introduced sulphurous acid gas; through the second, oxygen; and through the third, nitrous gas (deutoxide of azote). While the globe was kept cool, by being plunged in iced water, no sulphuric acid was formed, though all the ingredients essential to its production were present. But on exposing the globe to a temperature of 100° Fahr., the four bodies began immediately to react on each other, and oil of vitriol was condensed in visible *striæ*.

The introduction of steam is a modern invention, which has vastly facilitated and increased the production of oil of vitriol. It serves, by powerful agitation, not only to mix the different gaseous molecules intimately together, but to impel them against each other, and thus bring them within the sphere of their mutual chemical attraction. This is its mechanical effect. Its chemical agency is still more important. By supplying moisture at every point of the immense included space, it determines the formation of hydrous sul-

phuric acid, from the compound of nitric, nitrous, sulphurous, and dry sulphuric acids. No sooner is this reaction accomplished, than the nitrous gas resumes its oxygen, from the continuous atmospherical current, and becomes again fit to operate a like round of transmutations with sulphurous acid, steam, and oxygen. The nitrogen (azote), which ought to be the only residuum in a *perfectly* regulated vitriol chamber, escapes, by its relative lightness, at the opening in the roof, or, more properly speaking, is displaced by the influx of the heavier gases at the entrance-pipe.

On the intermittent plan, after the consumption of each charge, and condensation of the product, the chamber was opened, and freely ventilated, so as to expel the residuary azote, and replenish it with fresh atmospheric air. In this system there were four distinct stages or periods:—1. Combustion for two hours; 2. Admission of steam, and settling, for an hour and a half; 3. Conversion, for three hours, during which interval the drops of strong acid were heard falling like heavy hailstones on the bottom; 4. Purging of the chamber, for three quarters of an hour.

By the continuous method, sulphuric acid may be currently obtained in the chambers, of the specific gravity 1·350, or 1·450 at most; for, when stronger, it absorbs and retains permanently much nitrous acid gas; but by the intermittent, so dense as 1·550, or even 1·620; whence in a district where fuel is high priced, as near Paris, this method recommended itself by economy in the concentration of the acid. In Great Britain, and even in most parts of France, however, where time, workmen's wages, and interest of capital, are the paramount considerations, manufacturers do not find it for their interest in general to raise the density of the acid in the chambers above 1·400, or at most 1·500; as the further increase goes on at a retarded rate, and its concentration from 1·400 to 1·600, in leaden pans, costs very little.

At about the specific gravity of 1·35, in Great Britain, the liquid of the chambers is run off, by the syphon above described, into a leaden gutter or spout, which discharges it into a series of rectangular vessels made of large sheets of lead,

of 12 or 14 lbs. to the square foot, simply folded up at the angles into pans 8 or 10 inches deep, resting upon a grate made of a pretty close row of wrought-iron bars of considerable strength, under which the flame of a furnace plays. Where coals are very cheap, as in England, each pan may have a separate fire; but where they are somewhat dear, the flame, after passing under the lowest pan of the range, which contains the strongest acid (at about 1·600), proceeds upwards with a slight slope to heat the pans of weaker acid, which, as it concentrates, is gradually run down by syphons to replenish the lower pans, in proportion as their aqueous matter is dissipated. The 3 or 4 pans constituting the range are thus placed in a straight line, but each at a different level, terrace like.

When the acid has thereby acquired the density of 1·650, or 1·700 at most, it must be removed from the leaden evaporators, because, when of greater strength, it would begin to corrode them; and it is transferred into leaden coolers, or run through a long refrigeratory worm-pipe surrounded by cold water. In this state it was introduced into glass or platinum retorts, to undergo a final concentration, up to the specific gravity of 1·842, or even occasionally 1·845, in consequence of slight saline impurities. When glass retorts are used, they are set in a long sand-bath over a gallery furnace, resting on fire-tiles, under which a powerful flame plays; and as the flue gradually ascends from the fire-place, near to which it is most distant from the tiles, to the remoter end, the heat acts with tolerable equality on the first and last retort in the range. When platinum stills are employed, they are fitted into the inside of cast-iron pots, which protect the thin bottom and sides of the precious metal. The fire being applied directly to the iron, causes a safe, rapid, and economical concentration of the acid. The iron pots, with their platinum interior, filled with concentrated boiling-hot oil of vitriol, are lifted out of the fire-seat by tackle, and let down into a cistern of cold water, to effect the speedy refrigeration of the acid, and facilitate its transvasion into carboys packed in osier baskets lined with straw. Sometimes, however, the

acid is cooled by running it slowly off through a long platinum syphon, surrounded by another pipe filled with cold water.

One of the characters of the good quality of sulphuric acid, *is its dissolving indigo without altering its fine blue color.* Sulphuric acid, when well prepared, is a colorless and inodorous liquid, of an oily aspect, possessing a specific gravity, in its most concentrated state, of 1·842, when redistilled, but as found in commerce, of 1·845. It is eminently acid and corrosive, so that a single drop will communicate the power of reddening litmus to a gallon of water, and will produce an ulcer of the skin when allowed to remain upon it. If swallowed in its strongest state, in even a small quantity, it acts so furiously on the throat and stomach as to cause intolerable agony and speedy death. Watery diluents, mixed with chalk or magnesia, are the readiest antidotes. At a temperature of about 600° F., or a few degrees below the melting point of lead, it boils and distils over like water. This is the best method of procuring sulphuric acid free from the saline and metallic matters with which it is sometimes contaminated.*

The affinity of sulphuric acid for water is so strong, that when exposed in an open saucer, it imbibes one-third of its weight from the atmosphere in 24 hours, and fully six times its weight in a few months.† Hence it should be kept ex-

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* See chapter V., Part III., article *Preparation of Chemic.*

† Dr. Dalton ascertained that the dilute acid could be concentrated to the specific gravity 1·814, at a temperature varying from 65° to 57°; whence he concludes that acid of such strength is capable of drying a vacuum when the temperature does not exceed 57°. By making similar experiments in air, he compared together the weights lost by ten grains of dilute sulphuric acid of the specific gravity 1·135, at three different periods of the day for six days, taking note of the dew-point and the temperature; and infers that when the affinity of space for vapor, or the evaporating force, is equal to 0·15 of an inch of mercury, it is just able to balance the affinity for water of sulphuric acid of the specific gravity 1·249.

The same skilful chemist instituted a series of experiments to ascertain whether the evaporation of water from dilute sulphuric acid is capable of being carried on to the same extent in air as in vacuo, and found that the evaporating force of air exerted upon such acid is less than that of a vacuum at the same temperature. He observes that his experiments offer conclusive evidence that the evaporation of water is not owing to the existence of a chemical affinity between the vapor of the

cluded from the air. If four parts, by weight, of the strongest acid be suddenly mixed with one part of water, both being at 50° F., the temperature of the mixture will rise to 300°; while, on the other hand, if four parts of ice be mixed with one of sulphuric acid, they immediately liquefy and sink the thermometer to 4° below zero. From the great attraction existing between this acid and water, a saucer of it is employed to effect the rapid condensation of aqueous vapor as it exhales from a cup of water placed over it; both standing under the exhausted receiver of an air-pump. By the cold produced by this unchecked evaporation in vacuo, the water is speedily frozen.

To determine the purity of sulphuric acid, let it be slowly heated to the boiling point of water, and if any volatile acid matter be present, it will evaporate, with its characteristic smell. The presence of saline impurity, which is the common one, is discovered by evaporating a given weight of it in a small capsule of platinum placed on red-hot cinders. If more than two grains remain out of 500, the acid may be reckoned to be impure.

M. Gay Lussac has recently made a valuable improvement in the process of manufacturing sulphuric acid, and for which his agent in England, M. Sautter, has secured a patent. The improvement consists in causing the waste gas of the vitriol chamber to ascend through the *chemical cascade* of MM. Clement and Desormes, and to encounter there a stream of sulphuric acid of specific gravity 1·750. The nitrous acid gas, which is in a well-regulated chamber always slightly redundant, is perfectly absorbed by the sulphuric acid; which, thus impregnated, is made to trickle down through another

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liquid and atmospheric air; but thinks that they favor the notion that the obstruction to this process in the open atmosphere is rather owing to the pressure than to the *vis inertiæ* of the particles of air. He is also of opinion that improvements will hereafter arise from this inquiry with regard to the economical management of the process of manufacturing sulphuric acid, which process would be greatly expedited by the regulated admission of steam into the condensing chambers kept at a constant high temperature. This, we have seen, has to a great extent been verified by MM. Clement and Desormes.

cascade, up through which passes a current of sulphurous acid, from the combustion of sulphur in a little adjoining chamber. The condensed nitrous acid gas is thereby immediately transformed into nitrous gas (deutoxide of azote) which is transmitted from this second cascade into the large vitriol chamber, and there exercises its well-known reaction upon its aeriform contents. The economy thus effected in the sulphuric acid manufacture is such that for 100 parts of sulphur 3 of nitrate of soda will suffice, instead of 9 or 10 as usually consumed.

Upon the formation of sulphated nitrous gas ($N O^2$, $3 S O^3$, $2 H O$), and its combination with oil of vitriol, the manufacture of hydrated sulphuric acid is founded. Either sulphur is burned in mixture with about one-ninth of saltpetre; whence along with sulphurous acid gas, nitrous oxide gas is disengaged, while sulphate of potash remains; thus $K O, N O^5 + S = S O^3 + N O^2, K O$. 2. Or, nitric acid in the fluid or vaporous form may be present in the lead-chamber, into which the sulphurous acid gas passes, in consequence of placing in the flames of the sulphur a pan, charged with a mixture of sulphuric acid and nitre or nitrate of soda. This nitric acid being decomposed by a portion of the sulphurous acid, there will result sulphuric acid and nitrous gas. By the mutual reaction of the sulphurous and nitric acids, sulphuric acid and nitrous gas will be produced: $N O^5 + 3 S O = N O^2 + 3 S O^3$. 3. Or, by heating sugar or starch with nitric acid, the mixture of nitrous gas and nitrous acid vapor which results, may be thrown into the chamber among the sulphurous acid. In any one of these three cases, sulphurous acid gas, nitrous acid vapors (proceeding from the mixture of nitrous oxide and atmospherical oxygen) and steam are mingled together; whence arises the crystaline compound of sulphated nitrous oxide with sulphuric acid, which compound subsides in white clouds to the bottom of the chamber, and dissolves in the dilute oil of vitriol placed there, into sulphuric acid, with disengagement of nitrous gas. This gas now forms, with the remaining atmospherical oxygen, nitrous acid vapors once more, which condense a fresh portion of sulphur-

ous acid gas into the crystaline compound; and thus in perpetual alternation.

Sulphurous acid gas does not act upon nitrous gas, not even upon the nitrous acid vapor produced by the admission of oxygen, if water be absent; but the moment that a little steam is admitted, the crystaline compound is condensed. The presence of much sulphuric acid favors the formation of the sulphated nitrous gas. These crystals are decomposed by tepid water with disengagement of nitrous gas, which seizes the oxygen present and becomes nitrous acid.

According to the analysis of Dr. Thomson, the crystaline compound deposited occasionally in the leaden chambers consists of—

Sulphurous acid,	0·6387,	or 3 atoms.
Sulphuric acid	0·5290	2
Nitric acid .	0·3450	1 atom.
Water . .	0·0733	1
Sulphate of lead	0·0140.	

He admits that the proportion of water is a little uncertain; and that the presence of sulphurous acid was not proved by direct analysis. When heated with water, the crystaline matter disengages nitrous gas in abundance; lets fall some sulphate of lead; and the liquid is found to be sulphuric acid. When heated without water, it is decomposed with emission of nitrous gas and fuming nitric acid; leaving a liquid which, mixed with water, produces a brisk effervescence, consisting chiefly of nitrous gas.

In looking at the present state of chemistry, it must be allowed that it exhibits a most promising aspect; the study of its abstract principles is calculated to keep the curiosity constantly on the alert, and awaken an intense and peculiar interest; and it is quite impossible to glance at its recent progress, and at the extraordinary discoveries which are daily rewarding the labours of its skilful cultivators, without anticipating most important consequences. Should its progress during the ensuing century only equal that of the past, it must lead to results deeply affecting the interests and welfare of mankind.

The following table, by Dr. Ure, shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute, at different densities:—

Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity.	Dry.
100	1·8460	81·54	66	1·5503	53·82	32	1·2334	26·09
99	1·8438	80·72	65	1·5390	53·00	31	1·2260	25·28
98	1·8415	79·90	64	1·5280	52·18	30	1·2184	24·46
97	1·8391	79·09	63	1·5170	51·37	29	1·2108	23·65
96	1·8366	78·28	62	1·5066	50·55	28	1·2032	22·83
95	1·8340	77·46	61	1·4960	49·74	27	1·1956	22·01
94	1·8288	76·65	60	1·4860	48·92	26	1·1876	21·20
93	1·8235	75·83	59	1·4760	48·11	25	1·1792	20·38
92	1·8181	75·02	58	1·4660	47·29	24	1·1706	19·57
91	1·8026	74·20	57	1·4560	46·48	23	1·1626	18·75
90	1·8070	73·39	56	1·4460	45·66	22	1·1549	17·94
89	1·7986	72·57	55	1·4360	44·85	21	1·1480	17·12
88	1·7901	71·75	54	1·4265	44·03	20	1·1410	16·31
87	1·7815	70·94	53	1·4170	43·22	19	1·1330	15·49
86	1·7728	70·12	52	1·4073	42·40	18	1·1246	14·68
85	1·7640	69·31	51	1·3977	41·58	17	1·1165	13·86
84	1·7540	68·49	50	1·3884	40·77	16	1·1090	13·05
83	1·7425	67·68	49	1·3788	39·95	15	1·1019	12·23
82	1·7315	66·86	48	1·3697	39·14	14	1·0953	11·41
81	1·7200	66·05	47	1·3612	38·32	13	1·0887	10·60
80	1·7080	65·23	46	1·3530	37·51	12	1·0809	9·78
79	1·6972	64·42	45	1·3440	36·69	11	1·0743	8·97
78	1·6860	63·60	44	1·3345	35·88	10	1·0682	8·15
77	1·6744	62·78	43	1·3255	35·06	9	1·0614	7·34
76	1·6624	61·97	42	1·3165	34·25	8	1·0544	6·52
75	1·6500	61·15	41	1·3080	33·43	7	1·0477	5·71
74	1·6415	60·34	40	1·2999	32·61	6	1·0405	4·89
73	1·6321	59·52	39	1·2913	31·80	5	1·0336	4·08
72	1·6204	58·71	38	1·2826	30·98	4	1·0268	3·26
71	1·6090	57·89	37	1·2740	30·17	3	1·0206	2·446
70	1·5975	57·08	36	1·2654	29·35	2	1·0140	1·63
69	1·5868	56·26	35	1·2572	28·54	1	1·0074	0·8154
68	1·5760	55·45	34	1·2490	27·72			
67	1·5648	54·63	33	1·2409	26·91			

The best test *for sulphuric acid*, and the soluble salts into which it enters, is the *nitrate of baryta*, of which 182 parts are equivalent to 49 of the strongest liquid acid, or to 40 of the dry, as it exists in crystalized sulphate of potassa. One twenty-thousandth part of a grain of the acid may be detected by the grayish-white cloud which baryta forms with it.

T.

TANNIC ACID is prepared as follows:—Into a long narrow glass adopter tube, shut at its lower orifice with a cotton

wick, a quantity of pounded galls are put, and slightly pressed down. The tapering end of the tube being inserted into a matrass or bottle, the vacant upper half of the tube is filled with sulphuric ether, and then closed with a ground-glass stopper. Next day there will be found in the bottle a liquid in two distinct strata; of which the more limpid occupies the upper part, and the other, of a syrupy consistence and amber color, the lower. More ether must be filtered through the galls, till the thicker liquid ceases to augment. Both are now poured into a funnel, closed with the finger, and after the dense liquor is settled at the bottom, it is steadily run off into a capsule. This, after being washed repeatedly with ether, is to be transferred into a stove chamber, or placed under the receiver of an air pump, to be evaporated. The residuary matter swells up in a spongy crystaline form of considerable brilliancy, sometimes colorless, but more frequently of a faintly yellowish hue. This is pure tannin, which exists in galls to the amount of from 40 to 45 per cent. It is indispensable that the ether employed in the preceding process be previously agitated with water, or that it contain some water, because by using anhydrous ether, not a particle of tannin will be obtained.

Tannic acid is a white or yellowish solid, inodorous, extremely astringent, very soluble in water and alcohol, much less so in sulphuric ether, and uncrystalizable. Its watery solution, out of contact of air, undergoes no change; but if, in a very dilute state, it be left exposed to the atmosphere, it loses gradually its transparency, and lets fall a slightly grayish crystaline matter, consisting almost entirely of gallic acid. For procuring this acid in a perfectly pure state, it is merely necessary to treat the solution thus changed with animal charcoal, and to filter it, in a boiling state, through paper previously washed with dilute muriatic acid. The gallic acid will fall down in crystals as the liquid cools.

If the preceding experiment be made in a graduated glass tube containing oxygen over mercury, this gas will be absorbed, and a corresponding volume of carbonic acid gas will be disengaged. In this case the liquor will appear in the

course of a few weeks as if traversed with numerous crystaline colorless needles of gallic acid.

Tannin or tannic acid consists of carbon 51·56; hydrogen 4·20; oxygen 44·24.

From the above facts it is obvious that gallic acid does not exist ready formed in gall-nuts, but that it is produced by the reaction of atmospheric oxygen upon the tannin of these concretions.—(See *Gallic Acid*, chapter II., Part III.; see also *Mordants*, chapter I. of the same Part.)

TARTARIC ACID.—This acid is much employed in calico-printing, and for making sodaic powders. It is prepared by adding gradually to a boiling hot solution of 100 parts of tartar, in a large copper boiler, 26 of chalk, made into a smooth pap with water. A brisk effervescence ensues, by the disengagement of the carbonic acid of the chalk, while its base combines with the acid excess in the tartar, and forms an insoluble precipitate of tartrate of lime. The supernatant liquor, which is a solution of neutral tartrate of potassa, must be drawn off by a syphon, and decomposed by a solution of chloride of calcium (muriate of lime.) 28½ parts of the dry chloride are sufficient for 100 of tartar. The tartrate of lime, from both processes, is to be washed with water, drained, and then subjected, in a leaden cistern, to the action of 49 parts of sulphuric acid, previously diluted with 8 times its weight of water; 100 of dry tartrate take 75 of oil of vitriol. This mixture, after digestion for a few days, is converted into sulphate of lime and tartaric acid. The latter is to be separated from the former by decantation, filtration through canvass, and edulcoration of the sulphate of lime upon the filter.

In decomposing the tartrate of lime, a very slight excess of sulphuric acid must be employed; because pure tartaric acid would dissolve any tartrate of lime that may escape decomposition. Bone black, previously freed from its carbonate and phosphate of lime, by muriatic acid, is sometimes employed to bleach or whiten the colored solutions of the first crystals.

The clear acid is to be concentrated in leaden pans, by

a moderate heat, till it acquires the density of 40° B. (spec. grav. 1·38), it is then run off, clear from any sediment, into leaden or stone-ware vessels, which are set in a dry stove-room for it to crystalize. The crystals, being re-dissolved and re-crystalized, become colorless six-sided prisms.

Tartaric acid, according to Dr. Ure's analysis, contains nearly 9 per cent. of combined water, and is soluble in two parts of water at 60°, and in its own weight of boiling water. This acid is much more easily decomposed by heat than oxalic acid; hence, it is apt to acquire a brown tinge, unless great care be taken to crystalize it in rather a low temperature.

When the tartrates are subjected to destructive distillation, they yield a quantity of empyreumatic oil, showing clearly that hydrogen enters as a constituent into the acid. The quantity of carbureted hydrogen and carbonic acid gases evolved, leaves no doubt that carbon and oxygen constitute the other two. Berzelius endeavored to determine the proportion of these constituents by burning a mixture of tartrate of lead and chlorate of potash in a glass tube, and collecting the products, which were as follows:—

Hydrogen .	3·807
Carbon . .	35·980
Oxygen . .	60·213
	100

According to Dr. Thomson's analysis, 9·375 grains of crystalized tartaric acid contain 3 grains of carbon. The 5 grains wanting to make up the weight must be oxygen. Thus it appears, that the constituents of 9·375 grains of crystalized tartaric acid are as follows:—

1 atom water	=	1·125
2 atoms hydrogen	=	0·25
4 atoms carbon	=	3
5 atoms oxygen	=	5
		9·375

In a series of experiments made by Dr. Prout, to determine

the composition of tartaric acid in crystals, the following results were obtained:—

3 atoms hydrogen .	0·375
4 atoms carbon .	3
6 atoms oxygen .	6
	9·375

Dr. Thomson's analysis, however, may be relied upon as the most correct; he repeated his experiments several times, with a view of obtaining correct conclusions on the subject, and gives as the true atomic weight of tartaric acid 8.25. Hence, the crystals must in reality be composed of

1 atom tartaric acid	8·25
1 atom water	1·125
	9·375

M. Braconnot, in a recent No. of the *Ann. de Chim. et de Phys.*, gives a most interesting paper on the *Isomeric modification of Tartaric Acid.* "It is well known," he says, "that tartaric and racemic (paratartaric) acids were the first well-defined examples of isomerism. The judicious reflections of M. Dumas on this extraordinary phenomenon have recalled a fact belonging to it, and which I had occasion to observe, respecting tartaric acid.

"Forty parts of this acid having been exposed for an instant to a considerable heat, they fused, swelled up, and left after cooling a dry yellowish matter, which was transparent like gum, and weighed 36·5 parts. This substance when softened by heat acquired great ductility, which allowed it to be drawn into threads as fine as hairs.

"This change of form, which recalls the dimorphism of sulphur, shows either a new molecular arrangement, or another isomerical modification. In fact, the tartaric acid thus submitted to the action of heat, no longer possesses its original properties; it is uncrystalizable, and is merely a thick viscid mucilage, which attracts moisture from the air.

"If this substance be dissolved in hot water, and carbonate

of lime be gradually added to saturate it, it does not form, as with common tartaric acid, a sandy deposit of crystalized tartrate of lime, but the solution becomes gradually turbid as it cools, and deposits a mucilaginous transparent insipid mass, which forms threads between the fingers like turpentine. This calcareous salt when dried is unalterable in the air, and resembles gum arabic. When heated in water or weak acetic acid, it softens, resuming its viscid and adhesive properties, without being sensibly dissolved; an excess of acid, however, redissolves it, especially when hot, and by evaporating the solution to dryness, there remains a dry, brittle, acidulous substance, which is transparent like a varnish, is unalterable by the air, and which, when immersed for some time in cold water, seems to undergo a molecular motion, which reproduces tartaric acid in its original state, for then there separates a sandy deposit of common tartrate of lime."

Such are the properties of the principal animal, vegetable, and mineral substances used in dyeing and calico-printing, a knowledge of which is of the highest importance to the practical man.—(See Appendix, article *Tartar*.)

PART SECOND.

OF BLEACHING.

CHAPTER I.

COTTON.

Necessity of Goods being a pure white—Processes of Bleaching—Old, Improved, and New Processes—Theory of Bleaching—Favorable influence of Light—Objections to Chlorine as a Bleaching Agent—Application of Chloride of Lime—Method of making Bleaching Powder—Destruction of its Bleaching properties, and the cause—Various methods of testing the qualities of Bleaching Powder—Objections to most of them—Remarks on Bleached Goods intended to be dyed delicate shades—Chemical nature of Bleaching—Erroneous opinions of authors upon this subject.

We have already had occasion to notice (in chap. II., Part I.), the necessity of goods being a pure white previous to being dyed any light *fancy** shade; otherwise the natural yellow color of the goods, whether cotton, silk, or woolen, would interfere with the particular shade wanted. If, for example, the shade required be a light pink upon cotton, and a little safflower be put upon it unbleached, the resulting color would not be a pink, but a shade intermediate between a salmon and a brick color, from the yellow ray reflected from the cotton mixing with the red reflected from the dye. We must, therefore, before dyeing a light pink, get rid of these yellow rays, and this is obtained by the process of bleaching.

* This is a technical term for fugitive colors, or colors not fast.

Hence, *the dyer must, of necessity, be also a bleacher*, and one, too, who has more to attend to than merely producing a good white; for as the substances used for bleaching are in general hurtful to the fancy colors, he must be very careful that the one process shall not interfere with the other.

These remarks, we think, will satisfy the reader of the importance of giving an outline of the process of bleaching, previous to describing the nature of the goods and processes for dyeing those colors which require to be dyed upon bleached goods. Black, vat blue, and green, do not require bleaching, except for some particular light shades of the two latter.

Where and when the practice of bleaching cloth first began to be practised we have no account; but we may reasonably suppose that, as soon as man became so far civilized as to manufacture clothing, the constant exposure of that clothing to the atmosphere, and occasional washing, would naturally suggest the idea of bleaching. However, we know that bleaching is of very ancient origin, mention being made of it in the oldest books extant. What was the nature of the process practised in these early times, is not clear; but from the earliest description to the close of last century no other process was known but alternate boiling, washing, and exposure to the atmosphere—a process which required a number of months to complete; but, since the application of chlorine to this purpose—an application which, as Graham observes, "is one of the most valuable which chemistry has presented to the arts"—the process is completed in a few days; nay, for the most of dyeing operations, in a few hours.

As many are now unacquainted with the routine of the process of bleaching previous to the introduction of chlorine, it may be worth while to give a short description of it, to illustrate the advantages obtained from the application of science to the arts. The first operation was that of steeping, which was merely immersing the yarn in hot water or cold alkaline leys. When water was used the steeping lasted for three or four days, but with alkaline leys forty-eight hours were sufficient; the goods were then washed, and boiled in

an alkaline ley for four or five hours, washed and exposed on the grass for two or three weeks, again boiled or *bucked*,* washed, and *crofted*.† These alternate operations of bucking, washing, and crofting, were generally repeated four or five times, each time reducing the strength of the alkaline leys in which the bucking was performed.

The next process was that of souring, which, till nearly the middle of last century, consisted in steeping the goods for several weeks in soured buttermilk. This process was much shortened by Dr. Home, who suggested the use of sulphuric acid (vitriol) instead of milk; and twelve hours, with a sour of this acid, were sufficient.‡ After the first souring, the operations of boiling, washing, souring and crofting, were repeated in regular rotation, until the yarn came to a good color, and was esteemed perfectly clear. A quantity of soap was generally used in the last operations of boiling. The number of times these operations were repeated varied according to the quality of the goods: linen was seldom finished in less than six months, cotton goods varied from six weeks to three months.

Various opinions were advanced to explain the nature of the chemical changes induced during these operations; but such opinions could only be hypothetical so long as the composition of the atmosphere and of water were not known—two substances which acted a very prominent part in these operations. And neither can we offer any explanation till once we are acquainted not only with the composition of the atmosphere and water, but also of the coloring matter upon the goods. Pure water is composed of oxygen and hydrogen, in the proportions by weight of eight of the former to one of the latter. The atmosphere is composed in the 100 parts by weight of 79 nitrogen, 20 oxygen; the remaining one being carbonic acid gas and watery vapor. The composition of the coloring matter of the goods has not as yet been very accurately ascertained; but, from several experiments made upon

* A technical term for boiling.

† A technical term for exposing on the grass.

‡ Home on Bleaching.

it, its properties are neutral, and will, therefore, be composed of equal portions of oxygen and hydrogen united to carbon; but, besides this coloring matter, there is also a resinous substance upon cotton which resists the action of water and makes it very difficult to moisten (*wet out*). This resinous substance is composed of hydrogen and carbon, and is soluble in alkalies and water, and is, therefore, mostly all taken out by steeping and boiling. These resinous and coloring matters do not form a part of the cotton, but mechanically adhere to it, so that substances may act upon and decompose them without in the least destroying the cotton; indeed, from a number of experiments, cotton is found as strong when deprived of these substances as before.

In order to ascertain the chemical changes which take place when goods are bleached in the air, Mons. Berthollet—finding that those seasons when most dew was deposited, were the most effective upon the color—examined the dew which falls from the atmosphere, and also that which transpires from the grass, and found both to contain a sufficient quantity of oxygen to destroy the color of turnsole paper.* What errors led to these results we do not know, for although dew did contain oxygen, it would not give its acid properties to redden turnsole paper. Or whether M. Berthollet considered the bleaching property of dew owing to its having free oxygen, or to this acid property, we do not know, not having seen the original details. The theory of croft-bleaching has been explained variously as follows:—

1. The oxygen of the atmosphere combines with the coloring matter of the cotton, forming a new substance capable of solution in water or alkalies, and comes off by washing or boiling; or it combines with some of the elements of the coloring matter, such as the carbon forming carbonic acid gas, which escapes into the air, or with the hydrogen and forms water; those elements which are left form either colorless substances, or substances soluble, in the next operation.

* Park's Chemical Essays.

2. The oxygen combines directly with the coloring matter, forming a permanent and colorless oxide.

3. That water acts otherwise than being merely a solvent; that it, or one of its elements, combines with the coloring substance, producing the effects noticed in the first proposition. Hence, dew being pure and free from any admixture which might retard this union, is better fitted for bleaching; consequently, the seasons when most dew is deposited, the bleaching process will be accelerated. Which of these theories is the true one we cannot say; but, from observation, light facilitates the process of bleaching, and this circumstance, we think, favors the supposition of the coloring matter being decomposed. Other interesting theories might be advanced from phenomena observed during the process of croft bleaching; and also the part the alkaline boils, and the sours take in the operation, but our space will not permit us to enter into details.

The modern process of bleaching, and that which is *now* almost universally practised, is by means of chlorine.* This substance was discovered in the year 1774, by Scheele, who also described its peculiar property of destroying vegetable coloring matters; but M. Berthollet was the first who called the attention of the public to its value as a bleaching agent, in 1785. About the time this chemist was prosecuting his inquiries into the nature of this substance, he was visited by the celebrated James Watt, to whom Berthollet related the

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* *Extemporaneous Solution of Chlorine.*—M. Tourtois gives the following quantities of ingredients for obtaining a solution of chlorine, which are to be added to an imperial quart of water, and well shaken together in a stoppered bottle; and he remarks, that unless the deutoxide of lead be finely powdered, some of it will remain undecomposed:—

Sulphuric acid	910 grains
Common salt	280
Deutoxide of lead . . .	840—*Journ. de Pharm.*

As, however, 280 of common salt contain 112 of sodium, requiring nearly 38 of oxygen for conversion into soda, and as 116 of deutoxide of lead give out only 4 of oxygen by reduction to protoxide, it will appear by calculation that 1102 grains of red lead should be used with 280 of salt, instead of only 840. The sulphuric acid must be equivalent to 150 of soda, and 1064 of protoxide of lead, or about 700 grains, instead of 910.

results of his experiments upon bleaching, and by this circumstance the inventor of the modern steam engine became also the introducer of the new process of bleaching into Great Britain.*

The introduction of chlorine as a bleaching agent, like all other discoveries which tend to overturn old practices, met with a host of oppositions. The most prominent objections offered were, that it destroyed the cloth—did not give a permanent white—and it killed the men who wrought with it. These oppositions were not altogether groundless, but the force with which they were urged hastened the improvements and effected remedies. The first method of using chlorine was by saturating cold water with the gas,—the water taking up about twice its volume of it. The goods were put in this water, after which it was heated to drive off the chlorine, or set it free, that it might act upon the coloring matter; but the goods being impaired by this process, even when the greatest care was taken, suggested the diluting of the chlorine water; which diluted liquor was found to bleach equally well, and the goods were preserved. The defect of the goods becoming yellow after a few days suggested alternate boiling with alkaline leys; and the difficulty arising from the workmen being unable to endure the effects of the escaping gas, led to the discovery that alkalies not only absorb a greater quantity of chlorine than water, but that they hold it with greater affinity, not allowing the gas to escape and affect the atmosphere, at the same time parting with it more regularly and effectively to the goods. The alkalies used were soda and potash, and each bleaching work had its regular apparatus of retorts and carboys, or wooden chests, for the purpose of making their own chloride of potash or soda. This practice is still continued in many print works, both in Scotland and England, for particular fabrics or delicate operations, as it is considered much safer, and better adapted for certain purposes, than the common bleaching powder. In the year 1798, Mr.

* Some give this honor to Professor Copland of Aberdeen; but, from the evidence we have seen it belongs to Watt.

Tennant, of Glasgow, patented a process for using a solution of lime for absorbing the chlorine instead of potash and soda; shortly after, the hydrate of lime (slaked lime,) was substituted for lime water, *and this is the preparation now used for bleaching, under the names of bleaching-powder and chloride of lime.* Other minor improvements have been made regarding the quantity of chlorine absorbed by the lime under certain conditions which will be noticed more particularly hereafter.

Notwithstanding all these discoveries and applications, the real nature of the decoloring agent was still unknown; it was prepared by digesting together a mixture of common salt, peroxide of manganese and sulphuric acid; a decomposition took place which was explained as follows:—The sulphuric acid combined with the soda of the salt and set the muriatic acid, which was in union with the soda, at liberty. The oxide of manganese gave off a part of its oxygen, which combined with the free muriatic acid and formed oxygenated muriatic acid—a name which was first applied to this new substance; but after being introduced into the arts this name was considered too unwieldy for common use, and was, therefore, contracted into *oxy-muriatic acid.* It was ultimately contracted by the workmen into *oxygen*, and, notwithstanding the discovery of Sir H. Davy, in 1811, that oxy-muriatic acid was not common muriatic acid with more oxygen, but a simple body which he called *chlorine*—the name oxygen is still given to bleaching powder, and all its preparations. We need scarcely tell the reader that this is erroneous, in so far as oxygen is the name of another element differing widely from chlorine both in its nature and properties. It is also a great evil to the workmen themselves, *by incorporating in their minds the properties of one substance with those of another.* We still remember the difficulty we were in when hearing that it was the oxygen of the air that supported life, and that it was the same oxygen which turned the green color of the goods while in the vat to blue when exposed to the atmosphere, and at the same time, seeing bleaching liquor, which was also termed oxygen, destroying blues, and felt that we

could not breathe its gas but with the greatest difficulty. To solve this puzzle, *every chemical book we could find was examined for remarks on oxygen;* but, to our mortification, not one of these remarks alluded to its bleaching properties. We doubt not but many others have been in the same dilemma. The following order will show our chemical friends the ridiculous position dyers and bleachers place themselves in by retaining such names:—

Glasgow, ———, 1840.

"Messrs. * * Will please send, at their earliest convenience, a cask of their strongest oxygen, containing as near as possible 2 cwt.; let it be newly made and dry, the last was damp, so that in a few days it became like as much clay, and lost the most of its strength."

Your attention will oblige,

Yours, &c., &c.

Chemic is a common name for bleaching liquor in many print works; and we know that there are many more erroneous names for other substances. There is, however, no better name for the substances we have been describing than *bleaching powder*, or, if in solution, *bleaching-liquor*.

It is sufficiently well known that the method of making bleaching-powder is *to expose the hydrate of lime* (*slaked lime*) *in fine powder to an atmosphere of chlorine, till the lime ceases to absorb more of the gas.* When the lime is in combination with an extra atom of water it will absorb much more chlorine than when it has just as much water as will slake it. The chlorine is passed into large vessels or chambers, furnished with shelves, upon which is placed the lime. Bleaching powder is white and pulverulent; it has a hot, bitter, and astringent taste, and a peculiar smell. When digested in water it leaves behind carbonate of lime, and some other impurities.

Some of the Continental chemists first suggested that the chlorine was not merely absorbed and retained by the lime, but that it combined with it and formed one or more definite compounds. This has led to a great deal of research, but

scarcely any definite conclusions—there being various compounds of chlorine which may be formed during the preparation of bleaching powder, and which possess bleaching properties as well as the chlorine alone; but the details of these researches do not come within our limits.*

The best bleaching-powder of commerce seldom contains above thirty per cent. of chlorine available in bleaching; but there are few substances which the dyer or bleacher use, more liable to change; indeed, from its first formation, there seems to be a constant chemical action going on between the chlorine and the lime; oxygen is disengaged, and chloride of calcium is formed—a substance which possesses no bleaching properties. These changes may be much retarded by keeping the powder perfectly dry, or by dissolving it in cold water, and keeping the solution excluded from the air. Chloride of lime (bleaching-powder) does not attract moisture from the atmosphere as is supposed by dyers, *but when exposed to the atmosphere*, it is changed more rapidly into the chloride of calcium, a substance that is very deliquescent, and allowing that the lime previously contained two atoms of water, which combining with the chloride of calcium, when formed, places this salt in the best circumstances for attracting more water from the air, thus hastening the destruction of the remaining chloride of lime. We have seen good bleaching-powder, by a little inattention, reduced to this state in a few weeks, and its bleaching properties almost totally destroyed.

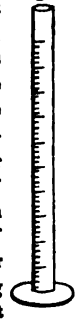
As chloride of lime loses its bleaching properties by standing, and several other circumstances, it is of the utmost consequence to the consumer, that he have some means of determining its real value, both for the sake of safety and accuracy in his processes, and its commercial worth. We have seen casks of bleaching powder which did not contain above ten per cent. of chlorine, charged and paid for at the same rate as that which contained thirty per cent.; but not having the means of testing it previously, the quality was not dis-

* Whoever feels interested in them, will find a series of papers upon the subject in the second volume of the "General Records of Science," by *Balard*.

covered till the salt was in solution; indeed we are not aware of any relative prices according to the quality of this article, although with a very little care, and trifling expense, the dyer may know the value of the article he is about to purchase, and of course only pay accordingly. The first method of determining the value of bleaching-powder was by sulphate of indigo, but the indigo solution alters by keeping, and is therefore objectionable. "Several exact methods," says Graham, in his Elements of Chemistry, "of which that in which sulphate of iron is used, appears to be entitled to preference. This method reposes upon the circumstance that the chlorine of chloride of lime converts a salt of the protoxide into a salt of the peroxide of iron. It is found by experience that ten grains of chlorine are capable of peroxidizing 78 grains of crystalized sulphate of iron." To determine the per centage of chlorine in a sample of bleaching-powder, according to Mr. Graham's plan, proceed as follows:—

Some good crystals of protosulphate of iron (copperas) are to be pounded and dried by pressing between folds of cloth; 78 grains are dissolved in about two ounces of water acidulated by a few drops either of sulphuric acid or muriatic acid; then 50 grains of the chloride of lime to be examined, are dissolved in about two ounces of water, by rubbing them together in a mortar, and the whole poured into a vessel graduated into a hundred parts. The common alkalimeter will do. This is straight glass, tube, or, generally, a very narrow jar about ⅛ths of an inch in width, and 14 inches high, mounted upon a foot, as shown in Fig. 2, capable at least of containing a thousand grains of water, and graduated into a hundred parts. The jar containing the 50 grains of chloride of lime is filled up to the highest graduation by the addition of water, and the whole is well mixed. The clear of this solution is gradually poured into the solution of sulphate of iron, till the latter is completely peroxidized. This is known by means of red prussiate of potash, which gives a blue precipitate with the protoxide, but not with the peroxide of iron. A white plate is spotted over with small drops of the prussiate; a drop of iron solution is mixed with one of these after every addition of chloride of lime; and the additions continued so long as the prussiate drops are colored blue. They may be colored green, but that is of no moment. When the iron is peroxidized, the number of graduations or measures of chloride of lime required to produce that effect is noted; the quantity of chlorine in the 50 grains of bleaching-powder is now known, being ascertained by proportion. Thus, if it required 68 measures of the bleaching solution, then as 68 is to 10, so 100 is to 14·7, the chlorine in the 50 grains of powder; this

Fig. 2.



being multiplied by two gives the per centage of chlorine in the sample, which is 29·4"*

Another process has been recommended by Gay Lussac, which combines simplicity with accuracy, and is coming into general use with the manufacturers of bleaching-powder, and is as follows:—

A solution of arsenious acid is made in muriatic acid, and diluted with water. On adding a solution of chloride of lime, the muriatic acid takes the lime; the chlorine decomposes the water, combining with its hydrogen, while the oxygen unites with the arsenious acid, and converts it into arsenic acid. When the arsenious solution is tinged with sulphate of indigo, and bleaching liquor added, there is no change takes place on the indigo until the whole arsenious

* The following method of determining the strength of bleaching salts has been recommended by the French Academy of Sciences:—"If we pour into a graduated tube, one measure of common ink, and then add successively, proceeding by *fourths*, ¼, ½, ¾, 1¼, 1½, &c. measures of water, we shall of course obtain inks more and more pale in the same proportion. Lines are to be drawn very near together on a sheet of paper, with the inks thus obtained; that is, for the sake of convenience, a line is to be drawn after each addition of the water, which method will readily give us lines growing regularly paler and paler in a fixed proportion. When this is done, we are to cut off with a punch, of the same size, small disks of the paper thus ruled, so that each disk shall contain lines of all the different strengths, from the deepest to the palest. If we now wish to determine comparatively the strength of a sample of chloride of lime (bleaching salts), we have only to take a small quantity of it, and wet it sufficiently to make a conical cake, the base of which must cover exactly one of the pieces of paper, upon which it must be suffered to stand for about five minutes. The number of lines effaced will then give the comparative strength of the chloride.

"As these trials are only comparative, we must always make use of the same ink; and a trial should have been previously made with paper ruled by it, and bleaching-powder, the strength of which had been accurately determined by other methods; this previous trial furnishes us with the standard of comparison. In the case of bleaching liquors (as Labarraque's disinfecting soda liquid, or the chloride of soda, &c.) a given quantity must be poured into a graduated tube; the trial piece of paper is then to be introduced into the same, and there to remain for a determinate space of time, to be acted on by the liquid. While the action is going on, it is better to cover the piece of paper by a wine glass or tumbler." Some chloride of lime furnished by Mr. de Rezé, from the de Vic mines, erased completely all the lines from a piece of paper, whilst the best chloride (of commerce) of Paris, destroyed only $\frac{3}{4}\frac{5}{6}$ths of the lines of a piece of paper ruled with the same ink.

acid is transformed into arsenic acid; but the first drop after this discolors the indigo.

The correctness of this test is founded upon the knowledge of what proportion of chlorine is necessary to oxidize the arsenious acid in the test solution. Various proportions have been proposed as the standard strength of the solution, but it does not matter much what proportions are used provided the operator knows what proportion of chlorine is necessary to transform it, and being careful always to have it the same. *The best proportions for general use are those that require the least calculation.* The following proportions we have found to do very well, and to be easily counted:—

Take one ounce of arsenious acid (common arsenic of the shops), and dissolve it by digestion for a few minutes at a boiling heat, in 24 ounces by measure of pure muriatic acid, then add 46 ounces by measure of distilled water; but in case of any loss by evaporation during digestion, it is better to have a vessel which contains up to a certain mark 70 ounces, and when the acid solution is put into it, to fill up to the mark with water. This may be bottled and put by as the standard test liquor. Every three ounces by measure of it are equivalent to twenty-five grains of chlorine.

When a sample of bleaching-powder is to be tried, two hundred grains are carefully weighed and dissolved in the manner already described, in twice as much water as will fill the alkalimeter, or any other vessel graduated into a hundred parts. Three ounces of the arsenious solution are measured out, and put into a glass jar or tumbler, and tinged with sulphate of indigo. The alkalimeter is now filled with the bleaching liquor, which is added slowly to the arsenious solution, stirring constantly, and watching every drop that is added for the decoloring of the indigo. If the sample be so poor in chlorine that one full of the alkalimeter will not change the color of the indigo, it may be filled again, and the process continued till the indigo is decolored, and the whole number of graduations taken to effect this carefully noted—the fewer the number of graduations required, the richer the sample is in chlorine. Now, as every three ounces of the test liquor contains arsenious acid equivalent to 25 grains of chlorine, if the hundred measures effect the change of the arse-

nious into the arsenic acid, the value of the sample is exactly 25 per cent.; in other words, every four graduations taken to effect this change indicates one per cent. of chlorine. These equivalents were practically determined, and may differ a little from the theoretical calculations by atomic numbers, but the difference does not vary above a half per cent., and is not of much consequence in practice. The following table will serve as a guide to those who may adopt our proportions:—

Measures.	Per cent.	Measures.	Per cent.	Measures.	Per cent.	Measures.	Per cent.
150	16·66	127	19·68	104	24·03	81	30·86
149	16·77	126	19·84	103	24·27	80	31·24
148	16·89	125	20·00	102	24·51	79	31·64
147	17·00	124	20·16	101	24·75	78	32·05
146	17·12	123	20·32	100	25·00	77	32·46
145	17·24	122	20·49	99	25·25	76	32·89
144	17·36	121	20·66	98	25·40	75	33·33
143	17·48	120	20·83	97	25·77	74	33·78
142	17·60	119	21·00	96	26·04	73	34·24
141	17·73	118	21·18	95	26·31	72	34·72
140	17·85	117	21·36	94	26·58	71	35·21
139	17·98	116	21·55	93	26·87	70	35·71
138	18·11	115	21·73	92	27·17	69	36·23
137	18·25	114	21·93	91	27·48	68	36·75
136	18·38	113	22·12	90	27·77	67	37·31
135	18·51	112	22·32	89	28·08	66	37·87
134	18·65	111	22·52	88	28·40	65	38·46
133	18·79	110	22·72	87	28·73	64	39·09
132	18·94	109	22·93	86	29·06	63	39·68
131	19.08	108	23·14	85	29·41	62	40·32
130	19·23	107	23·36	84	29·76	61	40·98
129	19·38	106	23·58	83	30·12	60	41·26
128	19·53	105	23.81	82	30·48		

The above table includes almost the whole range of per centage of the bleaching powder of commerce; but should the dyer meet with any not included in the table, the per centage may be calculated as follows. As the number of measures is to 100, so is 25 to the answer required. Say, for example, the measure is 160,

then 160 : 100 : : 25 : 15·62.

Any of the two methods just described, may be performed in a few minutes; and in a substance that is liable to such deterioration, it is surely of importance that the purchaser have

some knowledge of the quality of the article he is purchasing, and that the workmen know something of the strength of the substances they are working with.* May not a certain price be fixed to a standard strength of bleaching powder, and to rise and fall according to the per centage of chlorine which it contains, in the same manner as practised with soda ash? it would at least save much annoyance, and the common complaint, "that the last cask was not so good as the former." The average per centage of good bleaching powder varies from 25 to 30 per cent. Was this average fixed at three pence per pound, which has been the constant price for years past in England, for bleaching powder, then that which contains from 20 to 25 would be 2½d., and from 15 to 20 the price would be 2d. Above 30 per cent. the value ought of course to rise in the same ratio. The adoption of some such plan, we are confident, would be satisfactory to all parties.

To prepare chloride of lime for bleaching, an aqueous solution is requisite. For this purpose, a quantity is put into a large vessel filled with water, and well stirred, and allowed to settle; this is termed the stock liquor. There are no definite proportions for making up this vat; every bleacher makes up his stock-vat to a certain strength indicated by Twaddell's hydrometer; a most fallaceous test, as the chloride of calcium, and every other article which is soluble in water, although it has no bleaching properties, affects the hydrometer. Care should be taken that this stock-vat be excluded from the air as much as possible, as the lime absorbs carbonic acid, and the chlorine being set at liberty, occasions considerable loss. This may be illustrated by putting a little upon a flat plate, and allowing it to stand a few days, when it will be found to have lost its bleaching power altogether.

Having the bleaching liquor prepared, the next process is the preparation of the alkaline leys. Some put in a quan-

* A prussic acid test has long been employed by Mr. John Mercer, of Oakenshaw, near Manchester. His test to mark the point at which the prussic acid becomes saturated, is the red oxide of iron. A bit of calico dyed buff with iron, is touched with the solution after each addition of the chlorine, and as soon as it ceases to become blue, enough of the chlorine has been added.

tity of carbonate of soda (common soda), or carbonate of potash (pearl ash), into the boiler where the goods are to be boiled, without any previous preparation. This may give a good enough white, but not so permanent; and if any oil be present, carbonated alkalies do not saponify it; it therefore remains in the cloth, and acts as a resist to any color that may be applied. The alkalies ought always to be made caustic previous to being used for bleaching. This is done by boiling the carbonated alkali with newly slaked lime; the lime combines with the carbonic acid of the alkali, and falls to the bottom, while the caustic alkali remains in solution. Without detailing the various methods practised, some of which are not good, we shall rather give what we consider the best. The carbonate of potash ought to be dissolved in no less than six times its weight. If less than the prescribed quantity of water be used, the potash is not deprived of its carbonic acid. The reason ascribed for this singular phenomenon is, that both caustic potash and its carbonate, have a strong affinity for water; and when less than six times its weight is used, there is sufficient water to supply the carbonate, but not the caustic, and hence, the carbonate is not converted into caustic. The exact quantity of lime is not material, provided there be enough. The lime ought to be added until a little of the liquor, diluted with water, is found not to effervesce upon the addition of an acid. If soda be the alkali used, five or six times its weight of water will do; but the combining proportion of this substance being less than potash, a much greater quantity of lime is required. The caustic solution is drawn into a vessel which is kept closely covered. Since the soda has been made on the large scale from common salt, a preference has been given to it for manufacturing purposes, owing to its cheapness. It is sold to dyers and bleachers as a dry white powder termed *soda ash*, which is a pure carbonate, and is prepared as follows:—

First, the common salt is converted into sulphate of soda by throwing 600 pounds of the salt into the chamber of a reverberatory furnace already well heated, and running down upon it from an opening in the roof, an equal weight of sulphuric acid of density 1·600 (150° Twaddle), in a moderate stream. Hydrochloric acid

(muriatic acid) is disengaged and carried up the chimney, and the conversion of salt into sulphate of soda is completed in four hours. Second, the sulphate thus prepared is reduced to powder, and mixed with an equal weight of ground chalk, and half its weight of coal ground and sifted. This mixture is introduced into a very hot reverberatory furnace—about two hundred weight at a time; it is frequently stirred until it is uniformly heated. In about an hour it fuses; it is then well stirred for about five minutes, and drawn out with a rake into a cast-iron trough, in which it is allowed to cool and solidify.

This is called ball soda, or British barilla, and contains about 22 per cent. of alkali. Third, to separate the salt from insoluble matter, the cake of ball soda, when cold, is broken up, put into vats, and covered by warm water. In six hours the solution is drawn off from below, and the washing repeated about eight times, to extract all the soluble matter. These liquors being mixed together, are boiled down to dryness, and afford a salt which is principally carbonate of soda, with a little caustic soda and sulphuret of sodium. Fourth, for the purpose of getting rid of the sulphur, the salt is mixed with one-fourth of its bulk of sawdust, and exposed to a low red heat in a reverberatory furnace for about four hours, which converts the caustic soda into carbonate, while the sulphur is carried off. This product, if well conducted, contains about 50 per cent. of alkali, and forms the soda ash of the best quality. Fifth, when crystalized carbonate of soda is wanted, the last salt is dissolved in water, allowed to settle, and the clear liquid boiled down until a pellicle appears on its surface. The solution is then run into shallow boxes of cast-iron to crystalize in a cool place, and after standing for a week, the mother liquor is drawn off, the crystals drained and broken up for the market. This mother liquor is evaporated to dryness, and forms a very impure soda ash containing about 30 per cent. of alkali.

Owing to various circumstances attending the manufacture of soda ash its per centage is very uncertain, varying from 30 to 50 per cent. This substance is generally priced according to its per centage. The per centage may be determined by some such means as we have just described for bleaching powder, that is, by having an acid exactly of the strength at

which 100 measures of it will saturate 100 grains of caustic soda, or the operator may proceed as follows :—

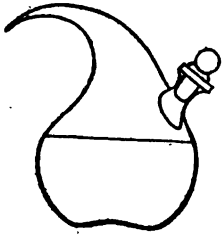
4 ounces avoirdupois of oil of vitriol are diluted with 20 ounces of water, or larger portions of acid and water may be mixed in these proportions. About three-fourths of an ounce of bicarbonate of soda is heated strongly by a lamp for a few minutes to obtain pure carbonate of soda, of which 171 grains are immediately weighed, that quantity containing 100 grains of soda. This portion of carbonate of soda is dissolved in 4 or 5 ounces of hot water, and the alkalimeter—the graduated tube described above—is filled up to the highest gradation with the dilute acid. The acid is poured gradually into the soda solution till the action of the latter upon blue litmus test paper ceases to be alkaline, and becomes distinctly acid, and the measures of acid necessary to produce that change are accurately observed; say it requires 90 measures. A plain cylindrical jar, of which the capacity is about a pint and a half, is graduated into 100 parts, each containing 100 grain measures of water, or ten times as much as the divisions of the alkalimeter. This jar is filled up with the dilute acid to the extent of 90, or whatever number of the alkalimeter divisions of acid were found to neutralize 100 grains of soda, and *water* is added to make up the acid liquid to 100 measures.

This forms a test acid of which 100 measures neutralize and are equivalent to 100 grains of soda, or one measure of acid to one grain of caustic soda. This acid ought to be kept in a well-stoppered bottle. By a curious coincidence, strong oil of vitriol diluted with 11 times its weight of water, gives this test acid exactly; but, as oil of vitriol varies a little in strength, it is better to form the test acid in the manner described than to trust to that mixture. Twenty-one measures of the test acid should neutralize 100 grains of crystalized carbonate of soda, and 68·5 measures 100 grains of pure anhydrous carbonate of soda. To test a sample of soda ash, proceed as follows :—

100 grains are weighed and dissolved in two or three ounces of hot water. The alkalimeter is filled with the test acid, and gently poured into this solution, stirring, as each drop is added, until a piece of blue litmus paper, which may be kept in contact with the liquor, is turned red. The number of gradations taken to effect this indicates the per centage of caustic alkali in the sample.

Another method of using this test acid is by weight. The acid is made to such a strength as one or two grains by weight will exactly neutralize one grain of pure alkali. The vessel commonly used for this purpose is of the annexed form, Fig. 3. It is filled with the test acid, and the whole

Fig. 3.



correctly weighed. The acid is then dropped from the small orifice into a weighed quantity of the carbonate until a neutral sulphate is produced. The bottle with its contents are then again weighed; the loss of weight gives, by calculation, the quantity of real alkali in the sample. Say that every two grains of the test acid are equivalent to one grain of pure soda, and that twenty-five grains of soda ash required twenty grains of acid to neutralize it, the real alkali present will be ten. Now 25 being the fourth of 100, the 10 is multiplied by 4, giving 40 as the per centage of the sample. This method *of testing carbonated alkalies is becoming very general;* and, provided the operator has a good balance, it is more correct than that with the graduated tube, and equally simple.

The following table, constructed by Dr. Dalton, will be found useful to the operative bleacher, showing the quantity of caustic soda in his solutions, indicated by the hydrometer (not Twaddell's):—

Density of solution indicated by Hydrometer.	Alkali per cent.	Density of solution indicated by Hydrometer.	Alkali per cent.
2·00	77·8	1·40	29·0
1·85	63·6	1·36	26·0
1·72	53·8	1·32	23·0
1·63	46·6	1·29	19·0
1·56	41·2	1·23	16·0
1·50	36·8	1·18	13·0
1·47	34·0	1·12	9·0
1·44	31·0	1·06	4·7

As the hydrometers generally used in dye-houses are those known by the name of Twaddell's, which is an arbitrary scale, the densities indicated in the above table may be reduced to Twaddell's scale by cutting off the first figure, and adding a cipher to the last two, and dividing this by 5, except the first number on the table, which is made 1000, and divi-

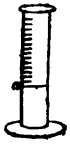
ded by 5. Let us, for example, take 1·18, which is a regular density for the caustic ley, we have 180 + 5 = 36, of Twaddell, which is a little more than 1 lb. of caustic soda to the gallon of water, and will require about 2¼ lbs. of soda-ash of 42 per cent. to the gallon of water, to give caustic soda of this density.

The first* operation in bleaching cloth is steeping it in a waste ley or tepid water for a number of hours, generally over night; this is termed the *rot* steep; its object is to loosen the paste and dirt that may have adhered to the cloth during its manufacture. This steep ought not to be hotter than blood heat, otherwise, if oil be upon the cloth, it is not saponified, neither is it so easily taken out after; in all cases when oil is observed, it ought to be taken out by rubbing it with soft soap and cold water previous to putting it into the steep. The goods are thoroughly washed from this steep in the dash wheel, but, if a wheel is not convenient, they are tramped in water, and then washed by rinsing them through water with the hands; they are then ready for the boiler. The boiling ley is made up by taking of the strong caustic ley, prepared as described above, a quantity equal to about six pounds weight of alkali to one hundred pounds weight of cloth, hav-

* All cotton goods, especially such as are to be printed, must in the outset be subjected to the operation of singeing, for the purpose of removing the fibrous down or nap. There are two methods, the old and new, of effecting this. The first consists in drawing the cloth swiftly over a red-hot semi-cylindrical bar of copper, three-quarters of an inch in thickness, placed horizontally over the flue of a fire-place, situated immediately at one end of the bar. The second, or new method, consists in passing the cloth rapidly through a coal-gas flame, for which a patent was obtained by Mr. Hall of Basford, near Nottingham, in the year 1818. The gas issues from numerous perforations through the upper surface of a horizontal tube, and the cloth to be singed is drawn over the flame rapidly by rollers. In the method first patented, the flame is drawn up through the web of cotton or other fabric by a flue leading into a common draught-chimney; but the draught not being always sufficient to draw the flame through immediately, an improvement in the apparatus was devised by Mr. Hall, and patented in 1823, which consisted in placing immediately over the gas-flame a horizontal tube, with a slit lengthwise through its lower surface, which tube is placed in communication with a fan or an exhausting apparatus. An arrangement of this kind, so constructed as to allow the passage of two pieces of cloth at the same time over two gas-flames, is capable of singeing, when properly managed, fifty pieces per hour.

ing as much water in the boiler as will allow the goods sufficient play when boiling;—they ought to boil for three hours. When goods are for light delicate colors, such as Prussian blues, the success of a bleach for such colors depends much upon a good boil. The goods are well washed from the boil and allowed to drain; the draining is facilitated by pouring hot water upon them; they are then hanked up, taking out all the twists, and laid into the bleaching liquor as loose as possible. The vessels which contain this liquor are large, made either of stone or wood, and are termed bleaching-vats or troughs. To prepare this liquor these troughs are filled with water, and a quantity of the stock-liquor added until the required strength is obtained, which is indicated by its action upon the sulphate of indigo, in what is termed the test-glass,—a vessel of the form represented in Fig. 4. It is filled to the mark *a* with the sulphate of indigo;—this indigo is generally supplied by the manufacturers of the powder as test blue; the liquor is added drop by drop until the color of the indigo is destroyed; the quantity taken to effect this as denoted by the graduations is termed its degree; two degrees are considered a fair strength for light goods, but, for heavy fabrics, it may be made stronger; they are allowed to steep in this for several hours, varying according to the nature of the goods.

Fig. 4.



The objections we had to the use of sulphate of indigo as a test in the former case, are equally applicable here. We have found this test to be very uncertain.

To return to the bleaching process.—The goods, being allowed to steep in the bleaching-liquor for some hours, are lifted and washed, after which, if they are thick, stout goods, they are put into *a sour* for a little, then washed, and go through the same operations of boiling, liquoring and souring, as before; but for all common fabrics, we have found it the best practice to *sweeten** the goods from the liquor, hank them anew, and put them back into a new liquor of the same

* Building the goods on a drainer, and pouring water upon them till the water ceases to taste of liquor as it comes from them, is termed *sweetening*.

strength, for a few hours, wash them from this, and allow them to steep for an hour in strong *sour* of vitriol and water—about 1¼ pint of the former to four gallons of the latter. *There is, perhaps, no single branch connected with the art of dyeing, upon which there is more difference of opinion than bleaching.* Every one has some peculiarity of his own. One thing, however, may be noticed; namely, the necessity there is of washing well from the liquor before *souring*, as any lime remaining upon the cloth will be formed into an insoluble sulphate, and resist the dye. Some maintain that this is of no consequence; in our opinion, it depends wholly upon the color which is to be dyed on the cloth. We have found that light pinks, light greens, light lavenders, and sometimes light blues, when not washed well from the liquor, were often full of white spots, which we ascribed to that cause; but, for other dark shades, we found no difference, and for colors to be dyed with the bichromate of potash (chrome), such as yellows, ambers, and orange, we seldom give them any *sour*, only washed from the first liquor, and then dyed.

Cotton, in the hank (yarn), when to be finished white, goes through the same process as cloth, with the exception of the *rot* steep; but, for dyeing, a quicker operation is adopted. All cotton yarn must be boiled in water *for three or four hours* previous to being dyed. Every ten pounds weight—constituting what is termed a bundle—is divided into six equal numbers of *spindles*, and hung upon wooden pins about three feet long and two inches thick; this is termed *sticking*.

The stock-liquor for yarn is generally prepared in a cask or pipe, containing about 120 gallons of water; to this is added about 20 lbs. of good bleaching-powder, stirred, and allowed to settle. A small tub, of a size in which a bundle is wrought freely, is termed a ten pound tub; this is filled nearly two-thirds full with boiling water, and a bucket or *pailful* (about four gallons) of the stock-liquor is added. The bundle is now let down as quick as possible, and turned over for about ten minutes, after which it is put through a second tub of the same size, with water made a little sour

by adding about an imperial gill of vitriol, and wrought for about five minutes. Being then well washed, it is ready to be dyed almost any light shade. *By this method two men can bleach and wash two hundred pounds weight of yarn in about three hours—what, by the other process of boiling, steeping, and scouring, would have occupied two days.*

Having detailed the present method of bleaching cotton goods for dyeing, we may say a little upon the chemical nature of these processes, previous to the discovery of the elementary nature of chlorine. When that substance was considered a compound of muriatic acid and oxygen, it was thought that the acid parted with its oxygen, which bleached by the same means, but more rapidly, as the air which we have described under croft bleaching. When the true nature of chlorine was discovered, the theory was somewhat changed; finding, as was then supposed, that chlorine did not bleach except water was present, it was considered that the chlorine united with the hydrogen of the water, forming muriatic acid, and the liberated oxygen bleached as described. Thus oxygen was still the bleaching agent.

The above theory is still maintained and supported by various analogies. We shall quote the following from Gregory and Liebig's edition of Turner's Chemistry, new edition, 1840:—"One of the most important properties of chlorine is its bleaching power. All animal and vegetable colors are speedily removed by chlorine, and when the color is once destroyed, it can never be restored.* Davy proved that chlorine cannot bleach, except water be present; thus dry litmus paper suffers no change in dry chlorine, but when water is admitted, the color speedily disappears. It is well known, also, that hydrochloric acid (muriatic acid) is always generated when chlorine bleaches. From these facts it is inferred

* In at least one case, however, which is that of indigo, the color is reproducible after having been discharged by chlorine, provided the quantity of chlorine applied to the indigo has been no more than sufficient to change the blue color to a buff, and not enough to destroy all color. The rich crimson color into which some preparations of indigo are changed by chlorine is also convertible into blue, though not to so deep a shade as the original indigo.—*Parnell.*

that water is decomposed during the process, that its hydrogen unites with chlorine, and that decomposition of the coloring matter is occasioned by the oxygen liberated. The bleaching property of binoxide of hydrogen, and of chromic, and permanganic acids, of which oxygen is certainly the decoloring principle, leaves little doubt of the accuracy of the foregoing explanation."

Another theory has been advanced, and equally, if not more tenable, by which the chlorine is supposed to act directly upon the coloring matter. The following is from Dr. Kane's work:—"Formerly it was considered that water was necessary for this bleaching, and that the chlorine combined with the hydrogen, while the oxygen of the water being thus thrown upon the organic substance, oxidized it, and formed a new body, which was colorless. We have shown, however, that this is not the case, but that the chlorine enters into the constitution of the new substance formed, sometimes replacing hydrogen, at others, simply combining with the colored body, and in some, the reaction being so complete, that its immediate stages cannot be completely traced."*

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* In most cases of the destruction of vegetable colors by chlorine, the decomposition is effected, without doubt, through the powerful affinity of chlorine for hydrogen, which may be manifested in two ways; 1st, in the direct abstraction of hydrogen from the organic substance, and 2dly, in the decomposition of water, the hydrogen of which unites with the chlorine to form hydrochloric acid, while the oxygen of the water decomposes the coloring matter, forming carbonic acid with its carbon, and water with its hydrogen. Chlorine does not bleach readily in the absence of all moisture, and hydrochloric and carbonic acids may generally be discovered among the products. In a few cases, however, the bleaching action of chlorine simply consists in the direct combination of the chlorine with the coloring matter to form a compound which is devoid of color.

Chromic acid is another powerful bleaching agent, which acts by affording oxygen to the coloring matter, becoming itself reduced to the state of green oxide of chromium. The color of the vegetable substance is even more readily destroyed than if chlorine had been applied.

Most vegetable coloring matters are also bleached by sulphurous acid in the presence of water. The action of this substance is not so energetic as that of chlorine, and differs from it essentially in the circumstance that the colors are not entirely destroyed, but may in general be restored by exposure to the air, or by the application of a stronger acid or an alkali.—*Parnell.*

This theory is also supported by several analogies, such as the action of chlorine upon indigo already noticed; but which of the changes alluded to by Dr. Kane takes place during the bleaching of cotton, is not yet known. Chloride of lime, says the same author, does not bleach, except an acid be present to combine with the lime, and set the chlorine at liberty; but this is only conditional. It is true, that if blue litmus paper be put into a solution of newly dissolved chloride of lime, it is not bleached; but if the solution be allowed to remain in contact with the air for an hour or two, the lime combines with the carbonic acid of the atmosphere; and if the blue litmus paper be put into this solution, it is instantly bleached by the liberated chlorine. Cotton that has not been boiled in alkalies, is acted upon as the litmus paper in both cases; but if the cotton has received a good alkaline boil, and is well washed, the bleaching process goes on although the bleaching-powder be newly dissolved. This shows that the alkaline leys effect a change upon the coloring matter. The nature of this change we are not as yet prepared to state: several opinions have been given, but they are hypothetical, and some of them contrary to the changes which are supposed to follow.

Whenever the cloth is put into the bleaching liquor, there are acids formed, the principal of which is the hydrochloric; but whether it is from the chlorine, combining with the hydrogen of the water, or the coloring matter of the goods, we cannot say,—the latter we think most probable. Our opinion is, that the chlorine combines with the hydrogen of the coloring matter; and according to a law we have several times alluded to, the remaining elements of the coloring matter form a new substance, which is soluble, and thus the whole coloring matter is taken off the cloth. In vats, where several hundred pounds weight of cotton have been bleached before changing the liquor, there is evidence of more substances remaining than merely a solution of muriate of lime; but what these are, we dare not as yet venture to assert. That the bleaching of cotton depends upon either oxygen or chlorine combining with the coloring matter, form-

ing a colorless oxide or chloride, is not consistent with the fact that bleached goods are lighter than goods merely boiled.

Such is an outline of the processes of bleaching cotton goods for dyeing, as practised in the most celebrated dye-works of Europe at the present day (1846), and it is, we imagine, more to be relied upon, than anything on the subject to be found in the books of our predecessors.—For further information upon subjects connected with this branch of industry, see the *Appendix*.

CHAPTER II.

LINEN.

Preparation of Flax and Hemp—Processes of Bleaching them—Simpson's Patent Process.

LINEN contains more coloring matter than cotton. The former loses nearly a third of its weight, while the latter loses not more than a twentieth. The fibres of flax possess, in the natural condition, a light gray, yellow, or blond color. By the operation of rotting, or, as it is commonly called, *water-rotting*, which is employed to enable the textile filaments to be separated from the boon, or woody matter, the color becomes darker, and, in consequence probably of the putrefaction of the green matter of the bark, the coloring substance appears. Hence, flax prepared without rotting is much paler, and its coloring matter may, in a great measure, be removed by washing with soap, leaving the filaments nearly white.

The substance which gives steeped flax its peculiar tint is insoluble in boiling water, in acids, and in alkalies; but it possesses the property of dissolving in caustic or carbonated alkaline leys, when it has possessed the means of dehydrogenation by previous exposure to oxygen. Hemp is, in this respect, analogous to flax. The bleaching of both depends upon this action of oxygen, and upon the removal of the acidified dye, by means of an alkali. This process is effected generally by the influence of air in combination with light and moisture acting on the linen cloth laid upon the grass: but chlorine will effect the same object more expeditiously. In no case, however, is it possible to acidify the color completely at once, but there must be many alternate exposures to oxygen or chlorine, and alkali, before the flax becomes

white. It is this circumstance alone which renders the bleaching of linen an apparently complicated business.

In order to avoid repetition, where washing is mentioned, it must always be understood that the linen is taken to the wash-stocks or dash-wheel, and washed well in them for some hours. This part of the work can never be overdone; and on its being properly executed between every part of the bucking, boiling, steeping in the chloride of lime solution, and souring, not a little of the success of bleaching depends. By exposure is meant, that the linen cloth is taken and spread upon the bleach-green for four, six, or eight days, according as the routine of business calls for the return of the cloth, in order to undergo further operations.

A parcel of goods consists of 360 pieces of those linens which are called Britannias. Each piece is 35 yards long; and they weigh, on an average, 10 lbs. each: the weight of the parcel is, in consequence, about 3600 lbs. avoirdupois weight. The linens are first washed, and then steeped in waste alkaline ley, after which they undergo the following operations:—

1st,	Bucked with 60 lbs. pearl-ashes, washed, exposed on the field.					
2d,	Ditto	80	ditto	ditto		ditto
3d,	Ditto	90	potashes	ditto		ditto
4th,	Ditto	80	ditto	ditto		ditto
5th,	Ditto	80	pearl-ashes	ditto		ditto
6th,	Ditto	50	ditto	ditto		ditto
7th,	Ditto	70	ditto	ditto		ditto
8th,	Ditto	70	ditto	ditto		ditto
9th,	Soured one night in dilute sulphuric acid, washed.					
10th,	Bucked with 50 lbs. pearl-ashes, washed, exposed on the field.					
11th,	Immersed in the chloride of potash or lime 12 hours.					
12th,	Boiled with 30 lbs. pearl-ashes, washed, exposed on the field.					
13th.	Ditto	30	ditto	ditto	ditto	ditto.
14th,	Soured, washed.					

The linens are then taken to the rubbing-board, and well rubbed with a strong lather of black soap, after which they are well washed in pure spring water. At this period they are carefully examined, and those which are fully bleached are laid aside to be blued, and made up for the market; while those which are not fully white are returned to be

boiled, and steeped in the chloride of lime or potash; then soured, until they are fully white.

By the above process, 690 lbs. weight of alkali is taken to bleach 360 pieces of linen, each piece consisting of 35 yards in length; so that the expenditure of alkali would be somewhat less than 2 lbs. for each piece, were it not that some parts of the linens are not fully whitened, as above noted. Two pounds of alkali may, therefore, be stated as the average quantity employed for bleaching each piece of goods.

The method of bleaching linens in Ireland is similar to the foregoing; any alteration in the process depends upon the judgment of the bleacher in increasing or diminishing the quantity of alkali used. But it is common, at most bleach-fields, to steep the linens in the chloride of lime or potash at an early stage of the process, or after the goods have undergone the fifth or sixth operation of bucking. By this means those parts of the flax which are most difficult to bleach are more easily acted upon by the alkali; and, as before noticed, souring early in very dilute sulphuric acid, assists greatly in forwarding the whitening of the linens. Mr. Grimshaw, calico-printer, near Belfast, was the first who recommended early souring, which has since been very generally adopted.

Mr. Richard Simpson of the Strand, London, obtained a patent in July, 1845, for an improved method of bleaching linen, yarns, and fabrics. These improvements consist in the employment of certain solvents, by which the yarns or fabrics of linen are to be prepared for bleaching, before the ordinary means or processes of bleaching are resorted to. These solvents are to be applied to the yarns or fabrics of linen in a preparatory process of boiling, prior to the goods being immersed in the ordinary bleaching materials.

The solvents to be employed are either simple acids, followed by solutions of soda-ash, or acids combined with soda-ash, in which the yarns or fabrics of linen are to be boiled for a space of time to be regulated according to circumstances, and the application may be varied according to the character or condition of the material to be acted upon.

A composition of solvents which has been found to an-

swer for this purpose, is made by 22 lbs. of sulphuric acid of the first quality and strength, diluted in 50 gallons of pure water, which are to be boiled together in a leaden vessel, and, whilst boiling, 1 cwt. of the best soda-ash is to be introduced into the liquor, by small quantities at a time. The effervescence having ceased, the mixture must be kept boiling until the soda-ash is quite dissolved; and then, the sediment having been allowed to subside, the liquor may be drawn off quite clear, in which state it will be fit for use; but, if desired, the liquor may be evaporated, and its essential properties crystalized into the state of salt.

When the solvent material is prepared for acting upon cloth or particular kinds of yarns, it may be desirable to render it caustic, which is done by adding to the above compound about half a hundred weight of lime, and an equal quantity of potash.

As cloths and yarns vary in quality, the patentee has thought it desirable to describe two or three ways (which have been found successful) of applying this material. First: for 10 cwt. of yarns, take 20 gallons of the prepared solvent liquor, and boil it in a sufficient quantity of water; when cold, throw in the yarns, and allow them to steep in the liquor for about twelve hours; then, after washing in clean water and squeezing the yarns, throw them into a tub of sours, prepared with about 2 parts of vitriol to 98 of water; let the yarns remain 5 or 6 hours in this solution, and then wash them in pure water and squeeze them, when the yarns will be ready for the usual process of bleaching. Second: for 10 cwt. yarns, take 20 gallons of the prepared liquor; throw in the yarns, and boil them in it for 2 or 3 hours; then wash and squeeze, and proceed with the sours as usual. Third: when the yarn is very inferior in quality, after submitting it to the first described process, boil it for two hours in a weak solution of soda-ash with a sufficient quantity of water. Fourth: instead of using the prepared liquor, steep the yarns for five hours in warm water (at about 68° Fahr.), in which water about two parts, by measure, of vitriol, to 98 of water has been previously mixed; then wash,

squeeze, and afterwards boil them for two hours in a weak solution of soda-ash. Fifth: for cloth and other fabrics, the caustic preparatiou may be desirable in which lime has been incorporated as above described.

With these instructions it is considered that an experienced bleacher will be enabled to vary the proportions of materials, and the time of boiling, according to circumstances arising out of the quality of the goods to be operated upon.

In the preparation of cloths for bleaching, a mechanical contrivance may be desirable, by which the cloths may be conducted by a series of small rollers, set in a pan or trough, filled with the caustic liquor above described, kept constantly boiling. Upon the machine a pair of squeezing-rollers should be mounted, between which the cloth may be made to pass, and then enter a second pan or vat, and in like manner be conducted, by a series of rollers, through a solution of soda-ash, kept boiling; and after again being squeezed by rollers, the cloth may be wound upon a portable beam-roller, ready to be taken to the bleaching apparatus.

The patentee does not, however, consider any of these machines to be new, but limits his claim of invention to the processes of preparing yarns and fabrics of linen for bleaching, as above described.

CHAPTER III.

SILK.

Cleansing the Silk from Gum—Action of Alkalies on Silk—Of Soap—Old methods of Scouring—China-white—Azure-white, and Thread-white—Sulphuring—Azuring—Gum of Silk—Erroneous opinions of Authors respecting it—Observations on Dyeing Silk—Best method of Scouring—Influence of Light—Bleaching by Steam.

SILK in its raw state, as spun by the worm, is either white or yellow of various shades, and is covered with a varnish, which gives it stiffness and a degree of elasticity. For the greater number of purposes to which silk is applied, it must be deprived of this native covering, which was long considered to be a sort of gum. The operation by which this coloring matter is removed is called scouring, cleansing or boiling. A great many different processes have been proposed for freeing the silk fibres from all foreign impurities, and for giving it the utmost whiteness, lustre, and pliancy; but none of the new plans has superseded, with any advantage, the one practised of old, which consists essentially in steeping the silk in a warm solution of soap: a circumstance placed beyond all doubt by the interesting experiments of M. Roard. The alkalies, or alkaline salts, act in a marked manner upon the varnish of silk, and effect its complete solution; the prolonged agency of boiling water, alone answers the same purpose; but nothing agrees so well with the nature of silk, and preserves its brilliancy and suppleness so perfectly, as a rapid boil with soap-water. It would appear, however, that the Chinese do not employ this method, but something that is preferable. Probably the superior beauty of their white silk may be owing to the superiority of the raw material.

The most ancient method of scouring silk consists of three

operations. For the first, or the *ungumming*, thirty per cent. of soap is first of all dissolved in clean river water by boiling heat; then the temperature is lowered by the addition of a little cold water, by withdrawing the fire, or at least by damping it. The hanks of silk, suspended upon horizontal poles over the boiler, are now plunged into the soapy solution, kept at a heat somewhat under ebullition, which is an essential point; for if hotter, the soap would attack the substance of the silk, and not only dissolve a portion of it, but deprive the whole of its lustre. The portions of the hanks plunged in the bath get scoured by degrees; the varnish and the coloring matter come away, and the silk assumes its proper whiteness and pliancy. Whenever this point is attained, the hanks are turned round upon the poles, so that the portion formerly in the air may be also subjected to the bath. As soon as the whole is completely ungummed, they are taken out, wrung by the peg, and well shaken; after which, the next step, called the *boil*, is commenced. Into bags of coarse canvass, called *pockets*, about 25 lbs. or 35 lbs. of ungummed silk are enclosed, and put into a similar bath with the preceding, but with a smaller proportion of soap, which may therefore be raised to the boiling point without any danger of destroying the silk. The ebullition is to be kept up for an hour and a half, during which time the bags must be frequently stirred, lest those near the bottom should suffer an undue degree of heat. The silk experiences in these two operations a loss of about 25 per cent. of its weight.

The third and last scouring operation is intended to give the silk a slight tinge, which renders the white more agreeable, and better adapted to its various uses in trade. In this way we distinguish the China-white, which has a faint cast of red, the silver-white, the azure-white, and the thread-white. To produce these different shades, we begin by preparing a soap-water so strong as to lather by agitation; we then add to it, for the China-white, a little annotta, mixing it carefully in; and then passing the silk properly through it, till it has acquired the wished-for tint. As to the other shades, we need only azure them more or less with a fine in-

digo, which has been previously washed several times in hot water, and reduced to powder in a mortar. It is then diffused through boiling water, allowed to settle for a few minutes, and the supernatant liquid, which contains only the finer particles, is added to the soap bath in such proportion as may be requisite. The silk, on being taken out of this bath must be wrung well, and stretched upon poles to dry; after which it is introduced into the sulphuring chamber, if it is to be made use of in the white state. At Lyons, however, no soap is employed at the third operation: after the boil, the silk is washed, sulphured, and azured, by passing through very clear river water properly blued.

The silks intended for the manufacture of blonds and gauzes are not subjected to the ordinary scouring process, because it is essential, in these cases, for them to preserve their natural stiffness. We must therefore select the raw silk of China, or the whitest raw silks of other countries; steep them, rinse them in a bath of pure water, or in one containing a little soap; wring them, expose them to the vapor of sulphur, and then pass them through the azure water. Sometimes this process is repeated.

Before the memoir of M. Roard appeared, extremely vague ideas were entertained about the composition of the native varnish of silk. He has shown that this substance, so far from being of a gummy nature, as has been believed, may be rather compared to bees' wax, with a species of oil, and a coloring matter, which exists only in raw silks. It is contained in them to the amount of from 23 to 24 per cent., and forms the portion of weight which is lost in the *ungumming*. It possesses, however, some of the properties of vegetable gums, though it differs essentially as to others. In a dry mass, it is friable and has a vitreous fracture; it is soluble in water, and affords a solution which lathers like soap; but when thrown upon burning coals, it does not soften like gum, but burns with the exhalation of a fetid odor. Its solution, when left exposed to the open air, at first of a golden yellow, becomes soon greenish, and ere long putrefies, as a solution of animal matter would do in similar circumstances.

M. Roard assures us that the city of Lyons alone could furnish several thousand quintals of this substance *per annum*, were it applicable to any useful purpose.

The yellow varnish is of a resinous nature, altogether insoluble in water, very soluble in alcohol, and contains a little volatile oil, which gives it a rank smell. The color of this resin is easily dissipated, either by exposure to the sun or by the action of chlorine: it forms about one fifty-fifth of its weight.

Bees' wax exists also in all the sorts of silk, even in that of China; but the whiter the filaments the less wax do they contain.

M. Roard has observed that, if the silk be exposed to the soap baths for some time after it has been stripped of its foreign matters, it begins to lose body, and has its valuable qualities impaired. It becomes dull, stiff, and colored in consequence of the solution, more or less considerable, of its substance; a solution which takes place in all liquids, and even in boiling water. It is for this reason that silks cannot be alumed with heat; and that they lose some of their lustre in being dyed brown, a color which requires a boiling hot bath. The best mode, therefore, of avoiding these inconveniences, is to boil the silks in the soap bath no longer than is absolutely necessary for the scouring process, and to expose them in the various dyeing operations to as moderate temperature as may be requisite to communicate the color. When silks are to be dyed, much less soap should be used in the cleansing, and very little for the dark colors. According to M. Roard, raw silks, white or yellow, may be completely scoured in one hour, with 15 lbs. of water for one of silk, and a suitable proportion of soap. The soap and the silk should be put into the bath half an hour before its ebullition, and the latter should be turned about frequently. The dull silks, in which the varnish has already undergone some alteration, never acquire a fine white until they are exposed to sulphurous acid gas. Exposure to light has also a very good effect in whitening silks, and is had recourse to, it is said, with advantage by the Chinese.

Carbonate of soda has been proposed to be used instead of soap in scouring silk, but it has never come into use. The Abbé Collomb, in 1785, scoured silk by eight hours' boiling in simple water, and he found the silks bleached in this way to be stronger than by soap, but they are not near so white. A patent has been taken out in England, by Mr. Samuel Brierely, of Salford, Lancashire, for bleaching them by steam. The mode of operating, which we give in the patentee's own words, is as follows:—

"The raw silk is first soaked in lukewarm soap-water, in a tub, for a sufficient space of time to soften the gum. After this the silk is to be taken in hanks (while wet) and hung on poles within a wooden chest, box, or closet, and, when closed, steam is to be admitted by means of a pipe leading from a boiler, the apparatus being furnished with safety valves, stopcock, and a cock for drawing off the condensed steam."

Dr. Ure says, that "the silk is exposed to the action of the steam for ten minutes only." The silk, however, should be allowed to remain a sufficient time to dissolve the gum, when it is to be washed in a weak solution of soap and water; and lastly, in clean water, until the impurities be entirely removed. This steaming process is, according to Dr. Ure, very generally practised by the English throwsters.*

It appears that the Chinese do not use soap in producing those fine white silks which are imported into Europe. Michel de Grubbens, who resided long at Canton, saw and practised himself the operation there, which he published in the Memoirs of the Academy of Stockholm in 1803. It consists in preparing the silk with a species of white beans, smaller than the Turkey beans, with some wheat flour, common salt, and water. The proportions are 5 parts of beans, 5 of salt, 6

* According to Parnell, the only operations to which silk cloth is subjected preparatory to being *printed*, are, "1, boiling in a solution of soap and soda to remove the 'gum;' 2, passing through dilute sulphuric acid; and 3, washing and drying;" but this should not be done upon goods that are to be dyed.

of flour, and 25 of water, to form this vegetable bath. The beans must be previously washed. It is difficult to discover what chemical action can occur between this decoction and the varnish of raw silk; possibly some acid may be developed, which may soften the gummy matter, and facilitate its separation.

CHAPTER IV.

WOOL.

Yolk of Wool—Its nature—Methods of discharging the Yolk—Care to be observed in Scouring Wool—Hirst and Newton's Patent Processes—Sulphuring—Mode of operating—Fraudulent Practices—Removing harshness from the Wool after Sulphuring—Bleaching Mousselaine-de-laines—Hebert's Improved Machine for Fulling Cloth.

Wool, like silk, is covered with a peculiar varnish, which impairs its qualities, and prevents it from being employed in the raw state for the purposes to which it is well adapted when it is scoured. The English give the name *yolk*, and the French *suint*, to that native coat: it is a fatty unctuous matter, of a strong smell, which apparently has its chief origin in the cutaneous perspiration of the sheep; but which, by the agency of external bodies, may have undergone some changes which modify its constitution. It results from the experiments of M. Vauquelin, that the *yolk* is composed of several substances; namely, 1, a soap with basis of potash, which constitutes the greater part of it; 2, of a notable quantity of acetate of potash; 3, of a small quantity of carbonate, and a trace of muriate of potash; 4, of a little lime in an unknown state of combination; 5, of a species of sebaceous matter, and an animal substance to which the odor is due. There are several other accidental matters present in sheep's wool.

The proportion of yolk is variable in different kinds of wool, but in general it is more abundant the finer the staple; the loss by scouring being 45 per cent. for the finest wools, and 35 per cent. for the coarse.

The yolk, on account of its soapy nature, dissolves readily in water, with the exception of a little free fatty matter, which easily separates from the filaments, and remains float-

ing in the liquor. It would thence appear sufficient to expose the wools to simple washing in a stream of water; yet experience shows that this method never answers so well as that usually adopted, which consists in steeping the wool for some time in simple warm water, or in warm water mixed with a fourth of stale urine. From 15 to 20 minutes of contact are sufficient in this case, if we heat the bath as warm as the hand can bear it, and stir it well with a rod. At the end of this time the wool may be taken out, set to drain, then placed in large baskets, in order to be completely rinsed in a stream of water.

It is generally supposed that putrid urine acts on the wool by the ammonia which it contains, and that this serves to saponify the remainder of the fatty matter not combined with the potash. M. Vauquelin is not of this opinion, because he found that wool steeped in water, with sal ammoniac and quick lime, is not better scoured than an equal quantity of wool treated with mere water. He was hence led to conclude that the good effects of putrified urine might be ascribed to anything else besides the ammonia, and probably to the urea. Fresh urine contains a free acid, which, by decomposing the potash soap of the yolk, counteracts the scouring operation.*

If wools are better scoured in a small quantity of water than in a great stream, we can conceive that this circum-

* Mr. Samuel Hirst, of Batley, recommends the following method of scouring wool, and for which he obtained a patent in March, 1829:—"A large cistern being procured and filled with human urine, the latter is allowed to stand in it for about six weeks, in order to produce fermentation; when this has thoroughly taken place, about four hundred gallons of the fermented urine is to be transferred to an iron still, with a block-tin worm passing through a refrigerator, of the usual construction; to this is to be added one pound of tallow, prepared from beef suet, for the purpose of preventing the froth that would otherwise arise in ebullition. This mixture is to be distilled, and whilst in operation about six gallons of the aqua ammonia thus produced, are to be drawn off into a cask, adding six pounds of the best mottled soap, previously dissolved." This will give it an opaque appearance, and produces, as the patentee asserts, an excellent saponaceous material for cleansing and dressing woolens. The casks should be bunged up to exclude the air.—(See chapter IV. Part V., article *Scouring or Renovating articles of Dress, &c.*)

stance must depend upon the nature of the yolk, which, in a concentrated solution, acts like a saponaceous compound, and thus contributes to remove the free fatty particles which adhere to the filaments. It should also be observed, that too long a continuance of the wool in the yolk water, hurts its quality very much, by weakening its cohesion, causing the filaments to swell, and even to split. It is said then to have lost its *nerve*. Another circumstance in the scouring of wool, that should always be attended to, is never to work the filaments together to such a degree as to occasion their felting; but in agitating we must merely push them slowly round in the vessel, or press them gently under the feet. Were it at all felted, it would neither card nor spin well.

As the heat of boiling water is apt to decompose woolen fibres, we should be careful never to raise the temperature of the scouring bath too near this point, nor, in fact, to exceed 140° F. Some authors recommend the use of alkaline or soapy baths for scouring wool, but *practical* people do not deviate from the method above described.*

When the washing is completed, all the wool which is to be sent white into the market, must be exposed to the action of sulphurous acid, either in a liquid or a gaseous state. In the latter case, sulphur is burned in a close chamber, in which the wools are hung up or spread out; in the former, the wools are plunged into water, moderately impregnated with the acid.

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* For the bleaching of mousselaine-de-laine goods, intended for printing, Mr. Parnell recommends to proceed as follows:—"The goods are first passed two or three times through a solution of soap and soda, at about the temperature 130° Fahr., and there exposed for several hours to the action of sulphurous acid gas," as already described. The goods are next passed through a very weak solution of caustic soda, dried, and usually impregnated with a dilute solution of tin, which imparts considerable brilliancy to the colors afterward applied to the goods. For this purpose, de-laines (which are formed of cotton and wool) are impregnated with two different solutions of tin consecutively, one intended to afford oxide of tin to the wool, the other to the cotton. The solution first applied is a mixture of perchloride of tin and muriatic acid, for the wool; the other is stannate of potash (a solution of oxide of tin in caustic potash), from which oxide of tin is precipitated on the cotton by passing the piece afterward through dilute sulphuric acid. For the finer work, the sulphuring of de-laines is usually performed twice."—*Applied Chemistry*, p. 172.

Sulphuring-rooms are sometimes constructed upon a great scale, in which blankets, shawls, and woolen clothes may be suspended freely upon poles or cords. The floor should be flagged with a sloping pavement, to favor the drainage of the water that drops down from the moistened cloth. The iron or stoneware vessels, in which the sulphur is burned, are set in the corners of the apartment. They should be increased in number according to the dimensions of the place, and distributed uniformly over it. The windows and the entrance door must be made to shut hermetically close. In the lower part of the door there should be a small opening, with a sliding shutter, which may be raised or lowered by the mechanism of a cord passing over a pulley.

The aperture by which the sulphurous acid and azotic gases are let off, in order to carry on the combustion, should be somewhat larger than the opening at the bottom. A lofty chimney carries the noxious gases above the building, and diffuses them over a wide space, their ascension being promoted by means of a draught-pipe of iron, connected with an ordinary stove, provided with a valve to close its orifice when not kindled.

When the chamber is to be used, the goods are hung up, and a small fire is made in the draught-stove. The proper quantity of sulphur being next put into the shallow pans, it is kindled, the entrance door is closed, as well as its shutter, while a vent-hole near the ground is opened by drawing its cord, which passes over a pulley. After a few minutes, when the sulphur is fully kindled, that vent-hole must be almost entirely shut, by relaxing the cord; when the whole apparatus is to be let alone for a sufficient time.

The object of the preceding precautions is to prevent the sulphurous acid gas escaping from the chamber by the seams of the principal doorway. This is secured by closing it imperfectly, so that it may admit of the passage of somewhat more air than can enter by the upper seams, and the smallest quantity of fresh air that can support the combustion. The velocity of the current of air may be increased at pleasure,

by enlarging the under vent-hole a little, and quickening the fire of the draught-stove.

Before opening the entrance-door of the apartment, for the discharge of the goods, a small fire must be lighted in the draught-furnace, the vent-hole must be thrown entirely open, and the sliding shutter of the door must be slid up, gradually more and more every quarter of an hour, and finally left wide open for a proper time. By this means the air of the chamber will become soon respirable.

Exposure on the grass may also contribute to the bleaching of wool. Some fraudulent dealers are accused of dipping wools in butter-milk, or chalk and water, in order to whiten them and increase their weight.

Wool is sometimes whitened in the fleece, and sometimes in the state of yarn; the latter affording the best means of operating. It has been observed that the wool cut from certain parts of the sheep, especially from the groins, never bleaches well.

After sulphuring, the wool has a harsh crispy feel, which may be removed by a weak soap bath. To this also the wool comber has recourse, when he wishes to cleanse and whiten his wools to the utmost. He generally uses a soft or potash soap, and after the wool is well soaked in the warm soap bath, with gentle pressure he wrings it well with the help of a hook, fixed at the end of his washing tub, and hangs it up to dry.

Mr. Wm. Newton, of Chancery Lane, London, obtained a patent, in December, 1841, for an improved apparatus for "scouring and dyeing wool, cotton, and other fibrous substances." These improvements will now be described.—In fig. 5, *a*, *a*, is a cylindrical vessel, made of iron or wood, or other suitable material, constructed strong enough to bear a pressure of from one to two atmospheres, and coated on the inside with some material not liable to oxidation, and incapable of giving out color or damaging the goods whilst under operation; *b*, is a false bottom, placed in the lower part of the vessel, and perforated with holes for the passage of the liquor; *c*, is a cover, closing the aperture, or man-hole, in the top of

the vessel, which is furnished with two loops. Into these loops, wedges *d*, *d*, are driven, which, at their extremities bear on the upper part of the vessel *a*, and thereby hold up and make fast the lid or cover *c*, in contact with the top of the vessel. A tube *e*, is placed vertically in the middle of the vessel, resting upon the false bottom; it is open at bottom and closed at top, and is pierced with holes all round, for a considerable distance down, in order to allow the liquid to escape, in radial directions, into the goods packed in the vessel round it. A pipe *f*, supplies the liquid to the vessel *a*, by a force-pump *g*, which raises it from the reservoir *h*, and forces it into the lower part of the vessel *a*. The liquor in the reservoir may be heated to any given temperature, in any convenient manner, if required; or the reservoir may be an open boiler. A cock *i*, is inserted into the upper part of the vessel, in order that the liquid may be discharged, after having passed through the goods under operation. A flexible pipe *j*, is to be attached to the cock, for the purpose of returning the liquid into the reservoir, after it has circulated through the apparatus. In the bottom of the vessel *a*, there is a pipe *i*, provided with a cock for emptying the vessel, after the operation is done. The wool or other substance on which the cleaning operation is to be performed, must be tightly packed in the vessel *a*, as at *m*, *m*, and the pump *g*, being set to work, the liquor will be forced through. In some cases it is more advantageous to employ a closed vessel, as at fig. 6, which represents a vertical section of the vessel *a*, having a perforated piston *p*, attached to a cross-head *g*, working within it by means of a screw *r*. It may be also found, in some cases, that the central pipe presents

Fig. 5.

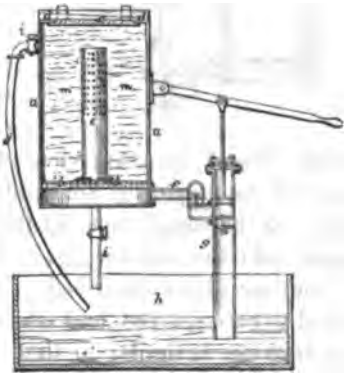
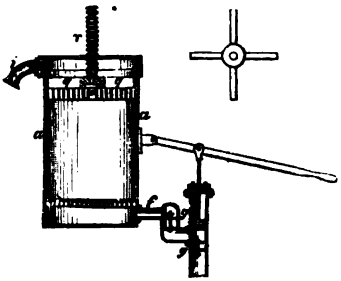


Fig. 6. Fig. 7.



too easy a passage to the liquid, which then does not act properly on the substances under operation. This apparatus is, therefore, modified accordingly. By turning the screw *r*, the cross-head and the piston are forced down upon the substances to be operated upon, which compresses them. Fig. 7, is a top view of the cross-head. The other parts of the apparatus are similar to those already described; viz., *f*, is the supply-pipe, for introducing the alkaline or other liquid into the vessel *a*; *g*, is a double-action pump, similar to the one above described. The reservoir, containing the liquid to be employed, and which has not been represented in the drawing, is similar to that shown at fig. 5; *i*, is the exit-pipe, for the escape of the liquid, after it has passed through the perforated piston *p*, to which a leather tube may be adapted, if necessary, in order to conduct the liquid into the reservoir, or direct it into any other vessel. The screw *r*, is of a sufficient length to give a suitable pressure to the goods placed in the vessels employed, and may be turned by any convenient means. In order to scour wool, packed in the vessel *a*, as described, in reference to fig. 6, an alkaline solution, or any other solution generally used for that purpose, is poured into the vat. The pump *g*, draws up this liquor, and forces it into the lower part of the vessel *a*, through the supply-pipe *f*. The liquor rises through the false bottom, ascends into the vessel *a*, and passes through the substances contained therein, and through the perforated piston, and ultimately escapes by the exit-pipe or cock *i*. The same liquid may be brought back by a pipe or tube into the vat, from whence it is again drawn, by means of the pump, and thus a continuous circulation of the liquor is produced, and constantly driven upwards through the fibres of the material to be operated upon. The same process and the same apparatus is employed for the bleaching of cotton yarns, fabrics,

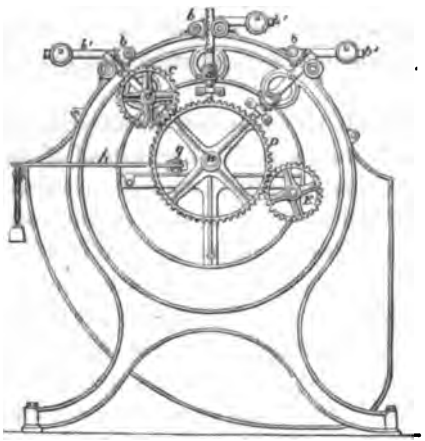
or other fibrous materials, the solution employed being varied according to the substances operated upon. An artificial current is, by these means, directed upwards, which constantly washes the fibres of the wool or other material, and carries away the greasy and coloring matter it has extracted, which, being constantly driven upwards, cannot enter the material again, as hitherto has been the case in the old mode of washing; the material, thus operated upon, is rapidly and most completely washed.

In the dyeing of wool, which has been previously scoured and washed, the same apparatus is used, only instead of an alkaline solution, a coloring bath, of the required strength, must be employed. This bath is to be heated in any convenient manner, either by steam or the naked fire. When the wool has been washed, as described, it is to be placed in the apparatus, fig. 6, and the screw *r*, turned, so as to press the piston tightly down upon the material; when, by means of the pump, the coloring solution is made to pass again and again through the wool under operation, until it has become completely saturated with the coloring matter. The discharging-pipe may then be opened, and the wool, completely dyed, may be removed from the apparatus. Those colors which require that the wool should be previously saturated with a chemical agent, may be operated upon by the agent being introduced into the apparatus in the same manner; and when this operation is finished, the coloring solution may be injected, as before stated, and continued passing through the material, as long as may be necessary, until the operation is completed.

Mr. Luke Hebert, of Birmingham, obtained a patent in September, 1841, "for an improved machine for fulling cloth." The advantages of this machine consist,. Firstly,—in the form and manner of applying the cylinders for fulling cloth, in the direction of its breadth, with a view to avoid the inconveniences which arise when pairs of *upper* and *lower* cylinders are employed for that purpose. Secondly,—in arrangements to insure the parallelism of the axis of the preparing-rollers. Thirdly,—in the form and construction of the trough,

in which the cloth is fulled, in the direction of its length. Fourthly,—in arrangements for combining fulling by pressure, with fulling by percussion. Fifthly,—in the substitution of other materials for wood or metal, in the construction of certain parts of the machinery. Fig. 8, is a side elevation of the machine; fig. 9, a longitudinal section of the same; fig. 10, an oblique section of a portion of fig. 9, with some modifications; and fig. 11, a vertical section of the same part, to give another view of the modification. A, is the great cylinder, formed of wood or copper, and mounted upon a shaft B, which turns in plummer-blocks, supported by the frame-work. Upon this shaft is fixed a wheel D, which is driven by a pinion E, fixed on the driving-shaft of the machine. Affixed to the sides of the cylinder A, are copper flanges, which, with the periphery of the cylinder, form a deep groove or channel; and into this channel the cloth is received and conducted under three small cylinders C, C, C^1, in succession; which, by their pressure, effect the fulling of the cloth laterally. The shafts of these cylinders turn in bearings a^1, on either side of the machine; the bearings are formed in racks a, (fig. 8,) the lower end of which slide in guides, fixed upon the outside of the casing. b, b, are toothed sectors, gearing with the racks a, a; and b^1, are levers, fixed to their respective axes, and fitted with moveable weights, for the purpose of regulating the pressure of the small cylinders upon the large one.

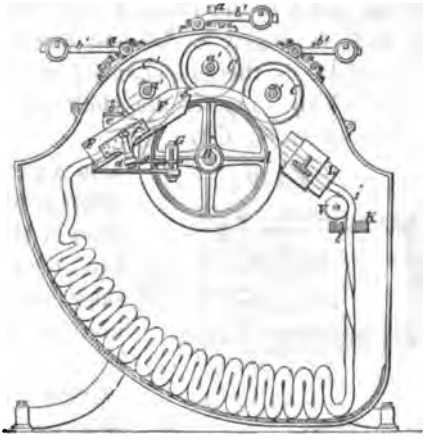
Fig. 8.



In order to sustain and guide the upper ends of the racks a, a, small grooved rollers are furnished, as shown at fig. 8. Upon the shaft of the cylinder C^1, is fixed a small wheel c,

which is driven by the wheel D, and thus insures the motion of the cylinder C¹, in its action upon the cloth, which, at this part, experiences a greater resistance, owing to the effect of the fulling longitudinally. *d*, is a shoe-piece, so formed that the cloth cannot get between it and the cylinder; its upper end (shown by dots in fig., 9,) detaches the cloth from the surface of the large cylinder, and throws it into the trough, in which it is fulled longitudinally. *e*, is an upper shoe, which serves the same purpose with regard to the cylinder C¹, as the lower shoe with respect to the cylinder A; this shoe *e*, is, by means of a cross-piece, attached to arms *e**, fitted with plummer-blocks, which turn upon the shaft of the cylinder C¹, and thus connect the cylinder with the shoe, in such a manner that whatever motion the cylinder may receive, the shoe will still remain in contact with it. The form and action of these shoes may be best understood by reference to fig. 11, which exhibits a modification of the expanding trough or channel. F, fig. 9, is one of two grooved plates or boards, forming the sides of the expanding trough; these plates are attached to the cheek-pieces *f*, which turn upon pivots in the arms *g*, of the bell-crank levers G; and the inner *f**, of the side plates is retained by iron rods *x*, fig. 10, attached by a screw to the side of the machine. To the arms *g*, of the bell-crank levers G, are fastened the bars *h*, to which the weighted cord, passing over a pulley, is attached; and which, acting upon the bell-crank levers, tends to close the sides of the expanding trough, and thus compresses the cloth in the trough with a force proportioned to the weight attached to the cord. K, is a board having a slot *l*, in it,

Fig. 9.



through which the cloth, coming from the cistern or lower part of the machine, is drawn, and is thereby gathered up. From thence the cloth passes through the rectangular tube L, which enables it to enter the trough or channel in the large cylinder A, more readily. The longitudinal aperture of the tube L, being placed so that its width shall cross the breadth of the slot *l*, in the board K, the cloth *i*, in its passage from K, to L, is pressed in different directions, and the disposition of its folds is thereby changed at each revolution. V, is a roller, which supports the cloth, at the proper angle, in its passage from K, to L.

Fig. 10.

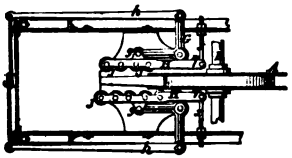
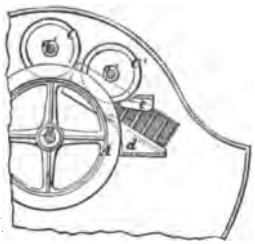
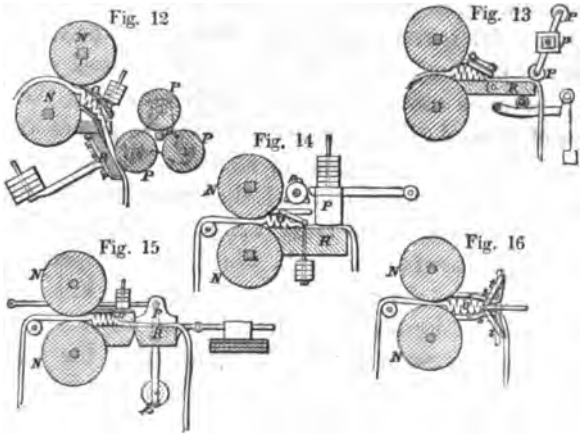


Fig. 11.



In figs. 10 and 11 is shown a different mode of constructing the sides of the expanding trough, in lieu of the grooved planks F; the sides are composed of two cast-iron plates H, H, in each of which is inserted a row of small grooved vertical cylinders J; these cylinders are so arranged that the projection of the cylinders in one row faces the recess formed by the contact of two cylinders in the opposite row. Figs. 12, 13, 14, and 15, represent various modifications of apparatus for fulling cloth by percussion. In all these figures the cloth is delivered by the rollers N, N, into a trough O, whence it passes to a table R, where it is subjected to the action of the beaters P. The cylinders N, N, may be considered as substitutes for the large cylinder A, and the small cylinders C, C, in the machine above described; they may be made much wider, and without flanges; their use may likewise be limited to simply drawing forward the cloth. The lower cylinder is driven in the same manner as the cylinder A. The bottom of the trough O, is fixed, but the top is hinged, and is kept down by a weight attached thereto, as in figs. 12, 14, and 15, or by a spring, as in fig. 13, thus op-

posing the free exit of the cloth from between the cylinders N, N, whereby the cloth is fulled lengthwise. The beaters P, may be made of various forms, and put in motion by various means ; thus in figs. 12, and 13, the beaters are of a cylindrical form, and each has its motion around its own axis in addition to its motion around the common centre *p*. In fig. 14, a mallet P, is set in motion by a cam *p* ; and in fig. 8, the mallet P, is moved by an eccentric or crank ; the force of the blow may be regulated by suspending the table R from a hinge, and giving it an upward pressure by a weight, as shown in figs. 12, 13, and 15: or the table may be a fixture, and the force of the blow regulated by weights, placed upon the beater, as in fig. 14.



In fig. 16, is shown another arrangement for fulling the cloth in the direction of its breadth. A portion *s*, *s*, of the top and bottom of the trough turns upon hinge-joints, forming clap-boards, and is connected to the rods *t*, *t* ; by the motion of which rods, the pieces *s*, *s*, are made alternately to recede from and to approach each other violently ; effecting by the shock a part of the fulling breadthwise, as is done by the cylinders before described. Fulling longitudinally is effected in this expanding channel as in the others. With a view to avoid, on the one hand, the evils caused by rust or oxidation when metal is employed in the construction of

some parts of the machine, or, on the other hand, those caused by alternate expansion and contraction when wood is so employed, the patentee prefers constructing portions of the machinery (more especially the troughs and cylinders) of stone, or such earthy materials as are susceptible of polish, such as granite, marble, glass, porcelain, or earthenware.

The operation of the machinery is as follows:—The cloth is first passed through the fixed channels, next between the cylinders, and then through the expanding trough; after which the two ends are sewed together. Upon setting the machine in motion, the cloth, lying in the cistern or bottom of the apparatus, is gathered up by the first fixed channel; whence, passing over the guide-roller, it enters the second fixed channel, the aperture of which, as before explained, is placed in a different position from that in the first, whereby not only is the cloth arranged so as to place itself, with more facility, between the rollers, but at each time that the same portion of cloth, in its successive revolutions, passes through these channels, the position of its folds becomes changed. From the second fixed channel the cloth passes into the channel or groove of the large cylinder, which, in its revolution, draws forward the cloth, which, passing between the large cylinder and the smaller ones placed over it, is fulled in the direction of its breadth, more or less, according to the pressure thrown upon the small cylinders by the weighted levers.

The third or last of the small cylinders (which, as before explained, is driven by a toothed wheel, in order to insure its action,) accumulates the cloth in the expansive trough, until the increase causes the two sides to recede slightly, and thus partially, and at intervals, to allow the cloth to pass through. In its passage through the expanding trough the cloth heaped up and folded back upon itself, becomes fulled lengthwise. In the case of the sides of the expanding trough being formed of small cylinders, as shown in figs. 10, and 11, in lieu of the grooved plates, shown in the first arrangement, the fulling is more rapidly and thoroughly effected, as, instead of one continued squeeze, each cylinder in suc-

cession, from their being placed in "quincunx," gives the cloth a squeeze.

In fulling by percussion, jointly with pressure, the beaters, contrary to the action of the common beaters, full the cloth, in successive portions, as it comes under their action, the force of which can also be regulated, either by weights placed upon the beaters, or by the degree of resistance given to the tables, according to the mode of construction employed.

Lastly, in fulling by the cylinders and clap-boards, the fulling, in each direction, is effected by successive violent approaches of the clap-boards, and the heaping and doubling up of the cloth between them by the action of the cylinders.

CHAPTER V.

Chlorimetry—Testing weak solutions of Bleaching-Powder—Testing by Arsenious Acid, or Green Copperas—Great danger of destroying the Goods—Care to be taken—Improved method of Testing.

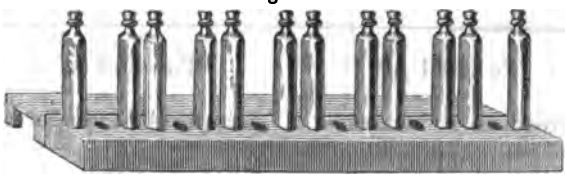
CHLORIMETRY requires to be practised by the bleacher for two purposes—First, he has to learn the commercial value of the bleaching-powder which he purchases; and with that view he can scarcely desire anything better than the method either by *arsenious acid* or *green copperas*, as already described. But the more important, because the hourly testing of his bleaching-liquor, and that on which the safety of his goods depends, is the ascertaining the strength of the weak solutions in which the goods have to be immersed. If the solution is too strong, *the fabric is apt to be injured.* If too weak, *part of the goods remain brown*, and the operation must be repeated. The range within which cotton is safe in this process is not very wide. A solution standing 1° on Twaddell's hydrometer, (spec. grav. 1·005,) is not more than safe for such goods, while that of half a degree is scarcely sufficient for the first operation of stout cloth, unless it is packed more loosely than usual. When the vessel is first set with fresh solution of bleaching-powder, there is little difficulty, if the character of the powder be known; but when the goods are retired from the steeping vessels, they leave a portion of bleaching-liquor behind, unexhausted, which must be taken into account in restoring the liquor to the requisite strength for the next parcel. The chlorimeter must, therefore, be applied every time that fresh goods are put into the liquid. It must, consequently, be intrusted to persons who may not be expert either in figures or in chemical manipulation. Hence the process is too delicate and tedious.

To obviate these difficulties, Mr. Walter Crum, of Thornliebank, near Glasgow, introduced, a short time ago, the following method, "*by which the testing is performed in an instant.*" It depends upon the depth of color of the peracetate of iron:—

A solution is formed of proto-chloride of iron, by dissolving cast-iron turnings in muriatic acid, of half the usual strength. To ensure perfect saturation, a large excess of iron is kept for some time in contact with the solution at the heat of boiling water. One measure of this solution, at 40° Twaddell, (spec. grav. 1·200,) is mixed with one of acetic acid. That forms the proof solution. If mixed with six or eight parts of water, it is quite colorless; but chloride of lime occasions with it the production of peracetate of iron, which has a peculiarly intense red color.

A set of phials is procured, 12 in number, all of the same diameter. A quantity of the proof solution, equal to $\frac{1}{6}$th of their capacity, is put into each, and then they are filled up with bleaching-liquor of various strengths, the first at $\frac{1}{12}$th of a degree of Twaddell, the second, $\frac{2}{12}$ths, the third, $\frac{3}{12}$ths, and so on up to $\frac{12}{12}$ths, or 1 degree. They are then well corked up, and ranged together, two and two, in a piece of wood, in holes drilled to suit them. We have thus a series of phials, showing the shades of color which those various solutions are capable of producing. To ascertain the strength of an unknown and partially exhausted bleaching-liquor, the proof solution of iron is put into a phial similar to those in the instrument, up to a certain mark, $\frac{1}{6}$th of the whole. The phial is then filled up with the unknown bleaching-liquor, shaken, and placed beside that one in the instrument, which most resembles it. The number of that phial is its strength in 12ths of a degree of the hydrometer; and, by inspecting the annexed table, we find at once how much of a solution of bleaching-powder, which is always kept in stock, at a uniform strength of 6 degrees, is necessary to raise the whole of the liquor in the steeping vessel to the desired strength.

Fig. 17.



The instrument is formed of long 2 ounce phials, as shown in fig. 17, cast in a mould; those of blown glass not being of uniform diameter. The outside, which alone is rough, is polished by grinding. They are placed two and two, so that the bottle containing the liquid to be examined may be set by the side of any one in the series, and the color compared

by looking through the liquid upon a broad piece of white paper stretched upon a board behind the instrument.

To explain the following table, it is necessary to state that the steeping vessels employed contain, at the proper height for receiving goods, 1440 gallons, or 288 measures of 5 gallons each,—a measure being the quantity easily carried at a time. In the table, 0 represents water, and the numbers 1, 2, 3, &c., are the strength of the liquor already in the vessel in 12ths of a degree of Twaddell, as ascertained by the chlorimeter. If the vessel has to be set anew, we see by the first table that 32 measures of liquor at 6° must be added to (256 measures of) water to produce 288 measures of liquor at $\frac{3}{12}$ths of a degree. But if the liquor already in the vessel is found by the chlorimeter to produce a color equal to the 2d phial, then 24 measures only are necessary, and so on.

To stand $\frac{3}{12}$°				To stand $\frac{6}{12}$°			
0	requires	32	measures.	0	requires	24	measures.
1	—	28	—	1	—	20	—
2	—	24	—	2	—	16	—
3	—	20	—	3	—	12	—
4	—	16	—	4	—	8	—
5	—	12	—	5	—	4	—
6	—	8	—				
7	—	4	—				

To stand $\frac{4}{12}$°				To stand $\frac{2}{12}$°			
0	requires	16	measures.	0	requires	12	measures.
1	—	12	—	1	—	8	—
2	—	8	—	2	—	4	—
3	—	4	—				

Let us see what takes place on mixing chloride of lime with protomuriate of iron. On the old view of the constitution of bleaching-powder—that it is a combination of chlorine and lime, we have

$$\left.\begin{array}{l} 3\ (CaO,\ Cl) \\ 6\ FeCl \end{array}\right\} \text{becoming} \left\{\begin{array}{l} 3\ CaCl \\ 2\ Fe_2Cl_3 \\ \quad Fe_2O_3 \end{array}\right.$$

the peroxide of iron forming peracetate with the acetic acid which is present. Or, supposing with Balard that when two atoms of chlorine unite with two atoms of lime, the product is CaCl+CaO, ClO, we have this formula :—

$$\left.\begin{array}{l} 3\ CaCl \\ 3\ (CaO,\ ClO) \\ 12\ FeCl \end{array}\right\} \text{becoming} \left\{\begin{array}{l} 6\ CaCl \\ 4\ Fe_2Cl_3 \\ 2\ Fe_2O_3 \end{array}\right.$$

Here one-third only of the iron goes to form the deep colored peracetate, while the whole might be employed for that purpose, by using protoacetate of protochloride. The latter, however, is preferred, from the greater tendency of the acetate to attract oxygen from the air, and, consequently, the greater difficulty of preserving it. Even with the chloride it is best to give out small quantities at a time, preserving the stock in well closed bottles.

PART THIRD.

DYEING PROCESSES.

CHAPTER I.

OF MORDANTS.

Mordants—Nature and application of—Scarcity of Mordants—Chemical union or combination of Mordants with stuffs—Near alliance of Dyeing to the science of Chemistry—Alum—Aluminous Mordants—Alumina, methods of preparing—Various qualities of Alum—Contamination of—Injurious effects on light shades—Advantage of substituting Acetic for Sulphuric Acid as its solvent—Remarks on Dyeing—Observations on drying goods containing Volatile Acids—Precautions to be observed—Dyeing Madder Red for Calico-Printing, by means of Acetate Alumina—Remarks on this process—Dunging and Washing supposed to extract the Mordant and leave the Base—Erroneous opinions of writers upon this subject—Preparation of the Acetate of Alumina—Mistaken Notions of Dyers—Tin Mordants—Messrs. Greenwood, Mercer, and Barnes', "Tin-preparing Liquor"—Plumb-tub—Yellow Spirits—Barwood Red Spirits—Mercer's Assistant Mordant Liquor—Union of Cotton with Coloring Matter.

MORDANTS.*—Did each dye-drug impart its own color to cloth, and did there exist a sufficient variety of these drugs for the various shades of colors, dyeing would be a very simple art, as it would only be necessary to dissolve the dye-stuff and impregnate the goods. But so far from this being the

* The term *mordant* is given to those substances which serve as *intermedia* between the coloring parts and the stuffs which they dye, either for facilitating or modifying their combination. It is by mordants, chiefly, that we diversify the colors, give them more brilliancy, fix them on the stuffs, and render them more durable.

case, if we except indigo, there is scarcely a dye-stuff that imparts its own color to goods; nay, the most part of the dye-drugs used have so weak an affinity for cotton goods especially, that they impart no color sufficiently permanent to deserve the name of a dye. These circumstances render dyeing sufficiently intricate, and make it more dependent upon science; indeed, it is only by the nicest arrangement of a few chemical laws, that the dyer is enabled to turn to advantage the various coloring matters of which he is in possession. When the dyer finds that there is no affinity between the goods and any coloring substance which is put into his possession, he endeavors to find a third substance, which has a mutual attraction for the cloth and coloring matter, so that by combining this substance with the cloth, and then passing the cloth through the dyeing solution, the coloring matter combines with the substance which is upon the goods, and constitutes a dye. This third substance used, and which acts as an intermediate, combining two inimical bodies, is termed a mordant from the French *mordre*, which signifies, to bite, from an idea which the old dyers had that these substances bit or opened a passage into the fibres of the cloth, giving access to the color. And although the theory of their action is now changed, the term is still continued, and perhaps further investigation will prove the term most applicable.

All the mordants, with *one* or *two* exceptions, are found among the metallic oxides. It may be supposed from this, that mordants are very numerous, but not so, for besides the necessity of their possessing a two-fold property—an attraction for both the goods and the coloring matter—they must also have the property of forming insoluble combinations, which property belongs almost wholly to insoluble bases; hence, we may perceive that the number of substances possessing all these properties is very limited.

The bases or oxides which are in general use, and which appear to succeed best, are alumina, the oxides of tin, and iron; the first two are colorless, the peroxide of the latter is a light brown, and imparts to white goods a buff or nankeen

color, which in many cases affects to a considerable extent the color of the cloth, a circumstance which must also be attended to by the dyer. Indeed the principal part of all dyeing operations is the proper choice and application of mordants, there being a chemical union between them and the coloring matter; a new substance is formed, not only differing in properties but differing in color from any of the originals; consequently, a very little alteration in the strength or quality of a mordant gives a decided alteration in the shade of color. However, it gives the dyer a much wider field for variety of shades; at the same time a less number of coloring substances is required; as, for example, logwood alone gives no color to cotton worthy the name of a dye; yet by the judicious application of a few different kinds of mordants, all the shades from a French white to a violet; from a lavender to a purple; from a blue to a lilac; and from a slate to a black, are obtained from this substance.*

Before any chemical union takes place between bodies, they must not only be in contact, but they must be reduced to their ultimate molecules; hence, mordants that are insoluble of themselves must be dissolved in some appropriate menstrua before their particles can combine either with the goods or the coloring matter. In doing this, the dyer must attend to the degree of affinity between the solvent and the mordant, to determine what force it will exert against the mordant combining with the fibres of the cloth; otherwise a powerful mordant may be weakened by the attraction of its solvent; as, for example, common alum, even though much concentrated, is but a weak mordant for cotton goods, owing to the great attraction between the sulphuric acid and the alumina. But if acetic acid, which has comparatively a weak affinity for the alumina, be substituted for the sulphuric acid, it becomes a very powerful mordant. From these things having to be attended to, the dyer has many beautiful illustrations of the relative attraction of different substances for

* See *Logwood*, chapter III. Part I.; see also *Black Dyes*, of this and the two following Parts.

each other. In some cases the attractions are so nicely balanced that the mordant and coloring matter may be kept mixed, and the goods, when immersed in this solution, having a kind of reciprocal affinity, only receive their share; do not extract the coloring matter from the solvent, but the depth of color upon the cloth corresponds with the color of the solution. In other cases the attraction between the mordant and coloring matter is so powerful that, if the least quantity of the mordant solution be upon the cloth when put into the dye, it seizes the coloring matter which is instantly precipitated or rendered insoluble, and, therefore, unfit to combine with the goods, and what coloring matter may have combined with the cloth before being all precipitated, will be uneven; that is, the resulting color will be light and dark. From these circumstances the reader will perceive *the near alliance the art of dyeing has to the science of chemistry;* but, an individual from experience may know these effects, and, though ignorant of the cause may guard against these consequences; *but knowledge, procured only by experience, is purchased at a very great cost,* and attended with many unpleasant circumstances. When the solvent of any mordant has such a powerful affinity for the coloring matter as to cause it to precipitate before it combines with the cloth, the goods must be well washed from the mordant solution. When this is done, although the mordant which is in combination with the cloth be sufficient to extract all the coloring matter of the dyeing solution, the resulting color is altogether impassible, being dull (without beauty,) at the same time so liable to change with every circumstance, that it could not be dried. To make this a little more plain we will detail a process. If a white piece of cotton be put through a dilute solution of chloride of tin (red spirits,) and from this put through a weak decoction of logwood, the coloring matter of the wood will be immediately precipitated, changing its hue to a violet color, very little of it combining with the cloth, and probably very unequally; but if the piece be thoroughly washed from the chloride of tin previous to putting into the logwood, the coloring matter of the wood will combine with the cloth, or

rather the metallic base which is on the cloth; and, provided the logwood solution corresponds with the strength of the mordant, the liquor will be left colorless; but the piece will be a light brownish shade.* If a little of the chloride of tin be now added to the liquor, its effects upon the logwood will be the same as if the piece had been put into it without being washed, but with this difference, that the coloring matter is in combination with the cloth, upon which it is not only changed to a violet color, but is rendered insoluble in water, and sufficiently permanent to constitute a dye. The substances thus added to the colored liquor to change and fix the colors are termed *alterants*,† in the technical language of the dyehouse *raising;* because it brightens the color. Alterants and mordants are often spoken of as two distinct substances; but the only distinction is the mode of applying them. In some instances distinct substances are used. In the process detailed above, a little alum would do as well as the tin; or if a particular bluish shade were wanted, a little pyrolignite of alumina; but in almost all cases the mordant may also be used as the alterant. As to the preparation of the mordants and the proper choice of solvents for them, the manner of applying these mordants whether hot or cold, and the best means of fixing them, such as drying, &c., will be noticed under their separate heads, so far as our knowledge extends. In prosecution of this plan we will begin with

ALUM.—This is what chemists denominate a double salt, being composed of two sulphates—the sulphate of alumina, and the sulphate of potash. This salt has been known, and in general use among dyers, since the earliest accounts

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* Why the metallic base is on the cloth after being washed, will be explained under *Tin*.

† In an extended sense, the term alterant may be applied to any substance which can effect a permanent change in the color of a dyed cloth, whatever may be its chemical action. Thus, oxalic acid becomes an alterant when applied to the purple woolen cloth obtained by cochineal with a mordant of protoxide of tin, whereby the purple becomes changed to scarlet; bichromate of potash may also be called an alterant when applied to a piece of cotton dyed violet with logwood and alumina, in order to change the violet into a black.—*Parnell.*

we have of their processes; but the true nature of its composition was not known till the present century. The alchymists knew that sulphuric acid was one of its constituents; and during the last century, it was discovered that the precipitate which falls down when the acid is neutralized by an alkali, is a particular kind of earth, which is called *alumina*.* It has been since discovered that alumina is the oxide of a metal called *aluminum*, which can only be obtained by a tedious and somewhat expensive process. Amongst other peculiar properties of alumina, it has a strong attraction for organic matter, and withdraws it from solutions with such force, that, if the purest water be not used in preparing this substance, it will be discolored; and when digested in solutions of vegetable coloring matters, provided the alumina be in sufficient quantity, it will carry down all the coloring matter from the liquid. By this means the pigments called lakes are formed (see chapter III., Part I.); and it is this makes it so valuable as a mordant. The fibre of cotton, when charged with this earth, attracts and retains the same coloring matters.

Alumina is easily dissolved in sulphuric acid, forming the sulphate of alumina, which crystalizes with much difficulty; but this salt has a strong affinity for the sulphate of potash; so that when these two salts are mixed, or when a salt of potash is added to a strong solution of sulphate of alumina, they combine, and form common alum, which is easily crystalized.

A very pure alum is obtained in the Roman states from *alum stone*, a mineral which is continually produced at the Solfatara near Naples, and other volcanic districts, by the

* This earth is thrown down as a white bulky precipitate when a solution of alum is mixed with an excess of ammonia. It is not obtained pure, however, by such a process, but retains some of the sulphuric acid. To prepare pure alumina, the precipitate as thus obtained may be redissolved in dilute sulphuric acid, and again precipitated by ammonia. The proper neutral sulphate of alumina is very soluble in water, and difficult to crystalize; by the addition of sulphate of potash, it becomes common alum, which is less soluble, and very easily crystalized.—*Parnell.*

joint action of sulphurous acid and oxygen upon some of the felspathic rocks. This mineral contains an insoluble subsulphate of alumina, with sulphate of potash; but it is partially decomposed by heat; so that, for the preparation of alum, the mineral is simply heated, till sulphurous acid begins to escape. It is then treated with water, by which process a very pure and excellent alum is procured.

The alum manufactured in Great Britain is almost always contaminated with sulphate of iron—a substance very deleterious to its use as a mordant. Iron may be detected by dissolving a little of the salt in distilled water, and adding a few drops of a solution of red prussiate of potash; or boiling a little, with the addition of a few drops of nitric acid, and adding yellow prussiate of potash. In both cases, a deep blue color is produced, if iron be present. When the proportion of iron is considerable, it is better to reject the alum altogether, especially if there be any chance of using it for bright light shades.* We have often experienced bad effects

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* "For some time past there has been introduced into the German market an alum said to contain, in a state of great concentration, the principles which are principally active in dyeing and printing. This quality, it is said, renders its employment more advantageous, and diminishes considerably the expense of transportation. This alum has not the least resemblance to the ordinary potash alum, for it presents no trace of crystalization, but is in flat quadrangular plates, about an inch thick; it is white, feebly transparent, and dissolves very easily in water; its taste is sweetish, bitter, and aluminous, but of less strength than that of ordinary alum. If pulverized sulphate of potassa is thrown into a concentrated solution of this alum, a crust of common alum forms directly. Mr. Mohr has found its composition to be,

Alumina . .	13·91
Sulphuric acid .	36·24
Potassa . .	1·50
Water . .	49·60

"We see by this composition that the alum in question is, properly speaking, but a pure sulphate of alumina with eighteen atoms of water of crystalization. A compound mentioned by Berzelius in his Traité de Chimie, and which in 100 parts contains 48·53 water of crystalization. It is probably prepared from pipe-clay, calcined and pulverized, and sulphuric acid, not entirely concentrated; the mixture is boiled to dryness in appropriate vessels, by a strong fire, whence its peculiar non-crystaline appearance. This new alum is altogether free from iron,

from the use of such alum upon light shades of drab and fawn colors, when dyeing to a particular pattern. Having obtained the particular shade, and adding a little alum as *raising*, the iron combined with the sumac upon the cloth, producing a color two or three shades darker than required; leaving no other alternative but to take off the color, and dye anew—a process much more difficult, and the color less brilliant, than at first. Alum is soluble in five parts of cold water, and in its own weight of boiling water.

The alum manufactured from the alum slate or shale, as we have already described, is a very weak mordant for cotton goods, owing to its containing an excess of sulphuric acid, which retains the alumina with great power; but if we neutralize a portion of the acid, so that no more will remain but what is necessary to hold the alumina in solution, which, according to experiment, requires only a third of the acid that is contained in common alum; this may be proved by taking a quantity of carbonate of soda, sufficient to neutralize the whole of the acid contained in a given portion of alum. Divide the soda solution into three equal portions, and add gradually aluminous solution, stirring all the time, two of these portions. It will be found that, although the alumina is at first precipitated, by keeping up the agitation for some time, the precipitate again dissolves, forming an alum containing only a third of the acid of common alum. In this state, alum is a very powerful mordant for cotton, as the base is held more feebly by the sulphuric acid, and is readily detached by the superior affinity of the cloth to form a mordant. Alum in this state is known by the name of *cubical* or *basic alum*, from the form in which it crystalizes. We have already referred to Roman alum being superior to other alums. For a long time, the dyers considered this

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and replaces the ordinary alum in all its uses; but it is for the preparation of the mordant, acetate of alumina, that it offers the most essential advantage. In fact, as it contains scarcely any sulphate of potassa, one-fourth the quantity of acetate of lead is saved in its decomposition by that salt, since the ordinary alum contains three atoms of sulphate of alumina and one of sulphate of potassa."—*Franklin Journal.*

superiority to be wholly owing to its purity; and it is only within these few years that chemists have found that it is of the same composition as the cubical alum.

The most common, and we believe, *the best*, method of using alumina as a mordant, *is, by substituting acetic acid for sulphuric acid* as its solvent. The acetate of alumina has several advantages over the sulphate:

1. The acetic acid possesses some analogous properties with alumina, in its action upon the vegetable coloring matter.
2. It holds the alumina with much less force than the sulphuric, and consequently yields it much easier to the cloth.
3. Being volatile, a great portion of the acid flies off during the process of drying.

When strong colors are wanted, and the mordant is of such a nature as will admit of being dried, it is better to dry from the mordant previous to dyeing. This last property of acetic acid is very convenient, as it frees the cloth from any superfluous acid which may have been in the mordant; besides, it has been found that during the drying, by heat, the soluble acetate is converted into a subacetate still more insoluble—and be it observed, high solubility is another very important qualification of a mordant. We may here put our brethren in mind of the following facts:—

That when goods containing volatile acids are drying, no other goods should be allowed to be in the same apartment, as the acid will combine with them, and will affect almost any color that either is or may be afterwards given them. Many unpleasant and also expensive consequences occur from the neglect of these matters.

During the various applications of these aluminous mordants, and the manipulation attending them, many curious and interesting chemical phenomena are witnessed by the dyer. Although his familiarity with them prevents altogether any particular remark, we shall instance one or two of those, attendant upon the process of dyeing madder reds, by means of *acetate of alumina.* This process, however, is more immediately connected with calico-printing (and will be noticed more at large when we come to speak upon that subject), while our particular object at present is dyeing to be finished as such:—The cloth to be dyed is first thoroughly bleached

and dried, it is then padded, or soaked in acetate of alumina about the specific gravity of 40° (8 Twaddell), and passed at full breadth through *nipping* rollers (squeezers). These are large rollers covered with cloth, which revolve one upon another. The pressure upon the piece as it passes through for the purpose we are describing, should be such that it will dry in five minutes, passing over rollers in a stove heated to 160° Fah. After being dried proceed in the following manner:—

1. The goods are passed through a dung bath, made up with about one part cows' dung to fifty parts water, at a heat of 130° Fah.; from this they are well washed through the dash-wheel.

2. Into a boiler of cold water is put from one to three pounds of madder, according to the color wanted, for every pound of cloth.

3. The cloth is put in, and a fire is kindled under the boiler, and so regulated that it will boil in two hours, during which the cloth is kept running over the *winch* or *reel*, first in one direction and then the other, and kept spread as much as possible, so that the whole surface may be equally exposed to the dyeing operation.

4. The boiler is kept at the boil from twenty to thirty minutes; this, with washing first through bran, and then water, completes the dyeing operation.

If a white pattern be wanted upon these reds, the pattern is printed upon the goods with citric acid, (about 25° of Twaddell, thickened with pipe-clay and gum)—about twelve or twenty-four hours* after being dried from the mordant. This decomposes the aluminous mordant upon these parts, so that no dye adheres to them afterwards. Now, from a difference in the manipulation, or a little variation upon some of these processes, several curious changes take place upon the mordant. For example, were the pieces merely washed with water from the mordant, previous to printing on the resist

* It is of the utmost consequence that the goods be thoroughly cooled previous to printing on the resist, otherwise there is danger of it not being successful. Pieces mordanted with acetate of alumina, and dried at a great heat, are highly charged with electricity. If the hand be suddenly drawn along the piece, *a complete shower of fire is observed, with a sharp cracking noise—at the same time a prickling sensation is felt.* Whether this has any effect upon the mordant, in its immediately combining with other substances, we do not know, but cloth in this state is very difficult to moisten: water runs off it as off a duck's wing, but as yet we offer no explanation, our researches not being complete.—(See chapter I, Part VI.)

acid, although the treatment be every way else the same, the discharge of the mordant is not effected, these parts upon which the citric acid is printed will be scarcely observable after the cloth is dyed, while in the other case they are perfectly white.

A somewhat similar result, in reference to the action of the discharge acid, takes place, if the heat of the stove in which the goods are dried from the mordant exceeds a certain temperature, or if dried upon steam rollers.* No acid, printed upon the cloth after this, will produce a white, except it be of a strength that will destroy the texture of the goods: besides this, the colors afterwards dyed upon mordants heated in this manner, are extremely bad, being heavy and dull.

Various opinions have been offered by practical men upon the probable cause of these changes: some suppose that by the excess of heat, the acetate of alumina is altogether decomposed, the acetic acid flying off, and the alumina left in union with the goods, which adheres with such an affinity that it requires a stronger acid than the cloth will bear to disengage it; but from the similarity of the effects which take place by merely washing the piece from the mordant, this opinion is liable to objection, for the sub-acetate of alumina is not decomposed by washing with water; however, different causes may produce the same effects. If the above opinion be correct, the circumstance of a bad color resulting from the acetate being decomposed, it will follow that it is not the alumina alone which constitutes a mordant, but its salt; in this case, it is the sub-acetate of alumina—the acetic acid being an essential ingredient to the dyeing process. This we are inclined to believe, for in those mordants, as we have already stated, where the acid can be separated by washing, the proper color is not produced until some salt or acid be added to the coloring matter as an alterant. It is supposed by some writers, *that the dunging and washing extracts the acid from the mordant, and leaves the base upon the cloth.*

* Large metal cylinders into which steam is admitted, and the cloth passed over the surface.—(See Calico-Printing, Part VI.)

This we conceive to be an error; for, although the part which dung acts in these processes is not well understood, yet from the analysis of this substance, and the nature of the salts which are supposed to be useful in these operations, there is no probability for the aluminous salt being decomposed. One principal use of the dung bath is to combine with and carry off any loose or supernatant mordant which may be upon the cloth, not combined, and which might affect the color, or more particularly, the parts wanted white.

The *acetate of alumina* is easily prepared by mixing a solution of acetate of barytes, lime or lead with alum. When any of these salts are added to alum, a double decomposition takes place; the sulphuric acid of the alum combines with the base of the salt which falls to the bottom; the acetic acid unites with the alumina, forming acetate of alumina, which remains in solution, mixed with the sulphate of potash which formed a constituent of the alum. The acetate of lead is the salt generally used for this purpose in the dye-house;* the proportions of the lead and alum vary according to the nature of the color to be dyed, and the peculiar taste of the dyer, for the preparation of this substance is one of those operations which every one who practices it thinks he has the best method, but so far as we have had an opportunity of knowing, the superiority only existed in the mind of the individual, or rather in its being kept secret.

The following method we have found to answer very well for general use:—

1. Into a boiler or pot put 20 lbs. of crystalized alum with about nine gallons water, and boil till the alum is completely dissolved.

2. In a separate vessel dissolve 20 lbs. of acetate of lead in about three gallons of boiling water. This is added to the alum while at a boiling heat, and well stirred. The sulphuric acid combines with the lead, forming an insoluble sulphate of lead, which falls to the bottom a heavy white precipitate—the acetate of alumina forms the clear liquor.

The difference in the preparation of this mordant is in the proportion of lead varying from one half of the alum to equal

* See Appendix, article *Acetate of Lead.*

weights. There is also added to the alum and lead a quantity of carbonate of soda varying from four to eight ounces to five pounds of alum. This is added for the purpose of neutralizing any excess of acid which may be present; but there are many dyers who will not use soda or any other alkaline substance when light bright shades are wanted, under the impression that the color is much brighter without alkalies, but the difference of hue is hardly perceptible. Some use lime; soda, however, is best—without soda or some other alkaline substance, the mordant is not so effective. There are also some who object to the use of soda, as it throws down the alumina; but we have already noticed under cubical alum, that a very little acid holds the alumina in solution; so that although soda, when added to the acetate of alumina, appears to precipitate the alumina, by a little agitation the precipitate is again dissolved, forming a mordant better adapted for strength of color. From the following recipes it will be observed, that the qualities of the aluminous mordants are similar both in England and France:—

ENGLISH.

100 pots boiling water, 100 pounds alum, 100 pounds acetate of lead, 10 pounds crystalized soda.	This mordant is best adapted for reds.

FRENCH.

100 pots boiling water, 100 pounds alum, 50 pounds acetate of lead, 6 pounds soda.	This is best for bright yellows.

In addition to the above, Dr. Ure in his Dictionary of the Arts and Manufactures, article "Calico-printing," gives another proportion:—

50 gallons boiling water.
100 pounds alum.
75 pounds acetate of lead.
10 pounds soda.

The following curious phenomenon was observed by Gay Lussac, viz., that the solution of a pure salt of the acetate of

alumina may be boiled without decomposition; but if sulphate of potash, or any other neutral salt of an alkali be present, the solution becomes turbid when heated, and a basic salt precipitates, which dissolves again on cooling. Now the acetate of alumina, prepared from the common alum, always contains sulphate of potash.* If by the presence of this salt a portion of the acetate of alumina be thrown down when hot, and being incorporated with the sulphate of lead, which falls in a very dense state, it may there be lost to the dyer. Whether this be so we know not, as we have not, since we knew of this phenomenon, had an opportunity of putting it to the test; but it would be advisable to stir the whole after becoming cold, that if any of this basic salt should be bound up with the precipitate, it might be set at liberty and dissolved; but it must be borne in mind, that if this be stirred when cold, it takes a long time to settle.

The most of the acetate of alumina used in dyeing is prepared from pyroligneous acid, and is called by calico-printers *red liquor*,† but by dyers *mordant*. No other substance, whatever be its nature, is distinguished as mordant. The pyroligneous acid is one of the products of the destructive distillation of woods.‡ The hard woods, such as oak, ash, birch, and beech, alone are used; they are put into large cast-iron cylinders, so constructed that a fire plays about them, so as to keep them at a red heat, having openings through which all volatile matter escapes by pipes, which lead into condensing vats. The matters thus obtained consist principally of pyroligneous acid, mixed with a black tarry matter, having a very strong smell, from which the acid had its name, although it has been long since known that it is simply acetic acid (vinegar). There is a great variety of other substances present, some of which have very singular properties, and some of the Continental chemists suppose they might be made available in dyeing. The products of the distillation of the woods are allowed to stand for some

* See Appendix, article *Alum*. † See *Calico-Printing*.
‡ See chapter V., Part I., article *Pyroligneous Acid*.

time, after which as much of the tarry matter as swims is skimmed off; the remainder is filtered, after which it is put into a boiler and heated a little, and lime added by degrees, till the acid is neutralized; then a quantity of lime is added in excess; the whole is then made to boil; this throws up the tarry matter to the top, where it is taken off; when it is purified as much as possible by this means it is syphoned off into another boiler, and a quantity of alum added; the acetate of lime, the sulphate of alumina and potash, mutually decompose each other; the sulphate of lime falls to the bottom; and the acetate of alumina remains in solution, which, when sent to the dyers, has generally a specific gravity of 1·90 (18 Twaddell), It has a dark brown color, and a very strong pyromatic odor. When the acetic acid is wanted pure, it passes through a number of other processes which do not come within our province to describe in this place.*

TIN.—This metal has nearly the color and lustre of silver; it is one of the few metals which were known to man at a very early period of his history, and was extensively used in all countries, both east and west, having any pretensions to civilization. This was probably owing to the ores of the metal being easily reduced to the metallic state, these being in general oxides; so that by merely fusing them with carbonaceous matter, such as coal, which combines with the oxygen, the metal is fused and sinks in the melted state to the bottom of the furnace.

The principal localities for obtaining tin, are Cornwall in England, Bohemia, Mexico, and the East Indies; the former of these has been wrought for many ages, and may almost be said to be the first nucleus of civilization in Great Britain, as it formed the great mart where the civilized and commercial Phœnicians obtained the tin which was so extensively used by them. The ore is found in Cornwall both in veins traversing the primary rocks, and in small rounded grains in the neighborhood of these rocks, imbedded in what geologists

* See Appendix, articles *Red liquor* and *Acetate of Alumina*, and *Aluminate of Potash*; see also Chapter V., Part I., article *Acetic Acid*.

term the *alluvial deposite.** This gives the purest tin, and is distinguished by the name of *stream* tin. The ore obtained from the veins is generally contaminated with other metals, such as iron, copper, arsenic, and the like, but is partially purified by liquation, that is, by heating the mass to the melting point of tin, which melts out and leaves the others. Several other operations of refining follow this, which need not be detailed; but there are always some little of the impurities remaining in a portion of the tin. That portion which contains these impurities, is termed *block* tin. The pure *grain* tin is heated till it becomes brittle, and is then let fall from a height, which splits it into small bars or prisms, in which state it is found in commerce. These bars in bending, make a peculiar crackling noise, and become heated. These phenomena are probably owing to the separating of its parts, and the sudden fracture caused by bending. Tin is very extensively used in dyeing and printing both *cotton* and *woolen*. The introduction of this substance as a mordant may be considered as forming an era in the art of dyeing, and like many other important improvements in this art, it was the result of accident, which is given by Berthollet as follows:—"A little while after the cochineal became known in Europe, the scarlet process by means of the solution of tin was discovered. It is stated that about the year 1630, Cornelius Drebbel observed by an accidental mixture, the brilliancy which the solution of tin gave to the infusion of cochineal. He communicated his observations to his son-in-law Kuffelar, who was a dyer at Leyden. He soon improved the process, kept it a secret in his work-shop, and brought into vogue the color which bore his name."

Soon thereafter, a German chemist found out also the process of dyeing scarlet by means of the solution of tin. He brought his secret to London in 1643; it became known to others, and was soon afterwards diffused over Europe, and its applications became more extended, and whenever a new dye

* Signifying the deposite formed by the washing away of the fragments of the primary rocks with water.

drug was introduced into the art, the solution of tin was universally applied, by which means it became a standard mordant for the various dye-woods, such as logwood, Brazil-wood, and the like.

The oxides of tin possess a similar property to alumina, in combining with astringent and coloring substances, and forming insoluble compounds. To obtain these oxides in a state applicable to dyeing, it is necessary to dissolve the metal in some acid, which is generally muriatic and nitric acid,* either separately or mixed, according to the substance to be dyed, or the coloring matter used. When an acid dissolves a metal, the metal is said to be first oxidized, either at the expense of the water or the acid, and the acid only combines with and dissolves this oxide. Thus, if nitric acid be used, it forms the nitrate of the oxide of tin, and when muriatic acid is used, it is the muriate of the oxide of tin; but with this last, the way of expressing it is conditional; even chemists do not altogether agree upon this point. Muriatic acid is composed of chlorine and hydrogen combined with water; when tin is put into this acid, there is an evolution of hydrogen gas. Whether this hydrogen be from the decomposition of the water or the acid, is not correctly known; if it be from the decomposition of the water, the salt is then a muriate of the oxide of tin; but if it be from the decomposition of the acid, the salt is simply a soluble chloride. This difficulty leads the student astray, as he sometimes finds in chemical works mention made of the chloride of tin, and none of the muriate, which, being most familiar with the term, he is searching for; but for all practical purposes, they are synonymous. The distinction followed by some is, that when the metal is dissolved in the acid, and kept in solution, such as is used by the dyers, it is a *muriate;* but when crystalized, or brought to a certain temperature, it is a *chloride.*

The solutions of tin, in the technical language of the dye-house, are termed *spirits*, with an affix to each mode of pre-

* These acids are described, under their proper heads, in chapter V., Part I., and to which the reader is referred.

paration, to denote their special application, such as red spirits, yellow spirits, plumb spirits, &c. The preparation of these spirits are matters of much pride amongst dyers, and each has some little peculiarity he keeps to himself, and to the virtue of which he supposes all his success depends. These peculiarities are generally in the proportion of the acids and the tin, and the manner of mixing them. However, as may be supposed, they are not all equally answerable for all purposes to which they are applied; hence the reason that we find one dyer best at reds, another at purples, another at blacks, and another at browns.

The first process in preparing spirits, is to *feather* the tin, and which is accomplished in the following manner:—

Melt the tin in an iron ladle and pour it when in this state into a vessel filled with cold water (a common tub will answer the purpose), the hand to be held as high as possible so that it may pour more in drops.

The appearance of the tin in this state is beyond description beautiful. By this process of feathering, a very extended surface of metal is exposed to the acid, which facilitates its solution very much.

Brazil-wood Red Spirits.—If red spirits be wanted, that is, *a mordant for dyeing red upon cotton by Brazil-wood*, the general method is as follows:—

Take three measures of muriatic acid, and one of nitric acid, then add the tin by degrees to this mixture. So long as the acids continue to dissolve it, care ought to be taken not to add the metal too rapidly, but bit by bit, adding one piece just as the other is dissolved.

We know that this is not generally attended to, as one handful of the metal is put in after another, at certain and too often irregular intervals of time, giving very annoying results. When the metal is put in too rapidly, or too much at once, the action becomes violent, the solution gets heated, the nitric acid is decomposed, ammonia is formed in the solution, and a quantity of peroxidised tin falls to the bottom when the solution cools, as a gelatinous precipitate, creating much loss. When spirits thus prepared are used for a brilliant red upon cotton by Brazil-wood, the proper hue is never obtained, the color being always more or less brownish. The

proportion of these acids for preparing the red spirits, are not invariably three to one, the mixture varies from half and half to five to one, depending upon the taste and experience of the dyer. Some also, only dissolve a given quantity of the metal to the pound weight of the mixed acids, varying from one and a half to three ounces to the pound; but according to our experience, the acids in whatever proportions they are mixed, ought to be saturated, at least so far as they will become saturated, observing the precautions described above. We have also found that when much nitric acid is used, the reds are generally deeper in color and have a very great tendency to turn brown, especially if the goods be dried in heat; but when the muriatic acid prevails, the color obtained has more of the crimson or rose tint, and is not so liable to brown in dyeing.

Although the solution of tin we have just described, is technically termed *red spirits*, it may with equal propriety be called *purple*, *brown*, *crimson*, nay, in many instances, *drab* spirits, for it is used for all these colors. If we take the goods prepared for red as detailed in chapter III., of this Part, under *Brazil-wood Red*, and put them through a decoction of logwood instead of Brazil-wood, we have a deep purple; if we use a mixture of logwood and Brazil-wood, we get a crimson, a marone, &c., according to the proportion of the mixture; if we use a decoction of quercitron bark, we get a deep yellow, and by working this yellow through a mixture of logwood and Brazil-wood, we have brown. Thus, the same mordant is made available to a great variety of colors; and we need hardly mention that by varying the strength of these decoctions, light and dark shades may be obtained of the same color, although when light shades of the same color are wanted, it is preferable to use weaker mordants.

When very light shades of purples, puces, and lilacs, are wanted, or lavender, violet, peach blossom, and the like, a different process is adopted. The logwood and the tin solution are mixed in certain proportions, and the goods require no previous mordant. This mixed solution is termed a

plumb tub, and by some a *French tub*, being first introduced by the French for the dyeing of silk. The *plumb* spirits are simply a protochloride of tin. The general proportions used by dyers are as follows:—

Seven measures of muriatic acid, and one water, adding two ounces of tin to every pound weight of the mixture; but in this, as in the others, care must be taken not to add the tin too rapidly.

It is well known to all who dissolve tin in muriatic acid in quantity, that if much metal be put into the acid at once, towards the end of the operation, parts of the metal seem to dissolve away, while other parts become coated with a white crystaline substance barely soluble, occasioning much annoyance and loss. This is caused by one part of the solution becoming denser than another; a galvanic action is induced between those parts of the tin in the weaker portion of the solution, and the parts in the stronger, consequently, depositing the tin from the solution upon the negative end, which is at the bottom, where the liquor is most saturated. This can be prevented by occasionally stirring the solution.

In the preparation of the plumb spirits, it is best to use pure muriatic acid without water, and to add the tin by degrees, and as long as the acid continues to dissolve it; and where it can be obtained without much cost, we would recommend the salt of tin being crystalized. It is sold in this state by many drysalters, but we have often found it in the market very impure.

A *plumb tub* is prepared as follows:—

A quantity of *chipped* logwood is put into a boiler or large pot filled with water; this is brought to boil, and kept boiling till the decoction has the density of at least 8° *Twaddell;* this is carefully decanted into a tall vessel, and allowed to stand for a few days to allow a quantity of tarry matter and other impurities to settle to the bottom. It is also of importance that the decoction be perfectly cold; for if at all above summer heat, a portion of the logwood will be precipitated on the addition of the tin. The decoction is again decanted into a suitable vessel, generally a large cask or wine-pipe; to this the chloride of tin or spirits is added until the hydrometer rises to 14°. If the chloride of tin has been crystalized, two or three degrees less will suffice and make a better plumb. After standing twenty-four hours it is fit for use. This forms a kind of stock vat, out of which portions are taken, and diluted or used strong, as occasion requires; it lasts a long time, as the goods do

not seem to extract the coloring matter from the solution as in other dyes, except by long immersion. When a mordant is upon them, they generally assume a color corresponding to the strength of the solution.

We will have occasion to notice (see *Black Dye* of this Part) the peculiar compound formed between the tin and logwood in this mode of combining them, when treating of logwood and its combinations; but we cannot help inquiring here upon what theoretical law does the dyeing by the *plumb tub* depend? It is not ordinary precipitation; for this compound is soluble, and is held in solution for years: we have known one kept two and a-half years, and used after. The goods have no mordant upon them previous to being immersed, and in a short time they obtain a dye sufficiently permanent to stand all the usual fatigues of fancy colors. That it is a chemical union between the compound constituting the *plumb tub* and the cloth *is not tenable;* for, as we have already shown, this cannot take place but between the atoms of matter, and at the expense of the original properties of the two substances, which combine. Now the cloth remains unchanged in properties except color, which may be taken off without in the least interfering with the properties of the cloth. Our opinion is, that in this, as in several other cases in dyeing, *the cloth exerts a catalytic influence over the compound of tin and logwood;* that is, a certain power of causing bodies in contact to combine or resolve themselves into other compounds, while the substance exerting the influence *is not affected;* as, for instance, a piece of platinum put into a mixture of oxygen and hydrogen, *will cause these two gases to combine and form water;* or a little sulphuric acid put into starch *will convert the starch into sugar*, without the acid being destroyed. So, in the same way, the cloth being put into this soluble solution of tin and logwood, may, by inducing a very slight transformation, *convert it into the insoluble compound of tin and logwood;* and, like other dyes, fills up the hollow fibres of the cloth, producing dark or light shades accordingly.

The *plumb tub* gives white goods the various shades, from a French white to a deep plumb, by dyeing the cloth first

light blue, and then immersing it in this preparation. Various shades of lilacs, puces, &c., are obtained by immersing the goods for some time in sumac, and then passing them through the plumb liquor. Various shades of peach blossoms are got in the same way. Thus, by a little manipulation, a great variety of shades and colors are produced by one costly preparation.

Yellow Spirits.—These are prepared in the same manner as the red spirits, only substituting *sulphuric acid* for nitric acid. This method of preparing the solution of tin was first recommended by Dr. Bancroft as a cheaper method of preparing scarlet spirits, but it was never much used for this purpose, but it was used for a long time for dyeing a deep yellow upon cotton with a decoction of quercitron bark; but the introduction of the *bichromate of potash*, as a dyeing agent, has almost entirely superseded every other method of dyeing yellow, as it combines within itself every qualification necessary to give it precedency, namely, beauty, durability, and cheapness.—(See *Yellow*, chapter III. of this Part.)

Barwood-Red Spirits are prepared in the following manner:—

Take six measures muriatic acid and one nitric acid, add tin by degrees until white bubbles begin to rise to the surface; allow this to stand for twelve hours before using.

This is the instruction generally given by *practical* barwood-red dyers for the preparation of their spirits; but this color being rather difficult to dye, except by much experience, owing to many peculiar properties of the barwood, we therefore refer the reader to chapter III. of this Part, article *Barwood-Red.*

Many other methods of dissolving the tin are practised by woolen and silk dyers, such as the following:—

Take six pounds nitric acid and one water, dissolve in this one pound of sal ammoniac, to which add ten ounces of tin.

The proportions of sal ammoniac and tin are points upon which practical dyers differ. Some use a little common salt

as well as sal ammoniac, but the resulting compound of tin is the same as in common red spirits. Sal ammoniac is composed of muriatic acid and ammonia; the nitric acid takes the ammonia, and the muriatic acid is set free and combines with the tin, forming what is termed *permuriate of tin.* The protosalts of tin, dissolved in potash, are extensively used in calico-printing, both as a mordant and a deoxidizing agent—a property which it possesses to a high degree; and, did its price not forbid, might be used instead of protosulphate of iron (copperas) in the common blue vat. Tartrate of tin is also used in many of the operations of calico-printing, and will be described when we come to speak of that department of the work.

Messrs. Greenwood, Mercer, and Barnes obtained a patent, in July, 1845, "for certain improvements in the manufacture of certain chemical agents used in dyeing and printing cotton, woolen, and other fabrics." These improvements consist, in the manufacturing stannate or stannite of soda or potash in a dry, crystaline, or pasty state, and in producing the "tin-preparing liquor" used for dyeing and printing fabrics (hitherto made by mixing oxymuriate of tin with dilute caustic soda), by dissolving the same in water. The following is the mode of manufacturing stannate of soda:—22 lbs. of caustic soda are first put into an iron crucible, heated to a low red heat by a fire beneath; then, after evaporation has taken place, so as to produce hydrate of soda, 8 lbs. of nitrate of soda and 4 lbs. of common salt are introduced; and when the mixture is at the fluxing heat, 10 lbs. of feathered block-tin are added, and stirred with an iron stirrer. The mass now becomes dark colored and pasty, and ammonia is given off (the tin decomposing the water of the hydrated soda and part of the nitrate of soda); the stirring is continued, as well as the application of heat, until deflagration takes place, and the mass becomes red-hot, and of a pasty consistence. This product is stannate of soda, which, being reduced to powder when cold, is ready for use; or, if it is required to be in a more pure state, it is dissolved and crystalized; or it may be dissolved and evaporated to a pasty state, so dry that no fluid

will run from it. Stannite of soda is made by putting 4 lbs. of common salt, 13½ lbs. of caustic soda, 1 lb. of nitrate of soda, and 4 lbs. of feathered block-tin into a hot iron crucible, over a fire and stirring and boiling to dryness; the stirring of the dry powder being continued as long as any ammonia is given off: this dry powder is *stannite of soda.*

To produce the "tin-preparing liquor," three pounds of stannate of soda are dissolved in one gallon of boiling water, and three gallons, or more, of cold water are added, to bring it to the required strength. The stannite of soda is used in the same way. The stannate or stannite of potash may be prepared in a similar manner to the stannate or stannite of soda.—The patentees claim, Firstly,—manufacturing stannate or stannite of soda and potash in a dry state, or in crystals, or in a state of paste. Secondly,—manufacturing stannate or stannite of soda by fluxing nitrate of soda or potash and tin. Thirdly,—making "tin-preparing liquor," for dyers and printers, by dissolving in water, stannate or stannite of soda and potash, which has been manufactured in a dry, crystaline or pasty state.—(See Appendix, article *Tin Mordants.*)

IRON.—As we will have occasion to notice the protosulphate of iron, and some of its peculiar properties and combinations, when treating of the blue vat: we will confine ourselves here to the properties of the metal as a mordant.

In the article referred to, the blue vat,* the reader will find two oxides of iron described, namely, the protoxide and peroxide; he will also find that both of these oxides combine with acids to form salts, but that the protoxide and protosalts, may be readily converted into the peroxide and persalts. Both of the salts are used as mordants, but the *protosalts* are the best for *vegetable* substances. It is, therefore, a matter of much consequence to preserve the iron in this state of oxidation until it be immersed into the dye-bath; this is effected in many instances by astringent sub-

* See chapter V., of this Part, article *Chemistry of the Blue Vat.*

stances. For example, in our detailed process of dyeing black,* the goods are steeped in sumac, then put through lime water; this turns the sumac on the cloth green, and converts some of its constituents into a state well fitted to combine with oxygen, which it will take from the atmosphere if exposed to it, thereby losing its green color and resuming the color it had when taken from the sumac. When the cloth is a deep green it will combine rapidly with the protosalts of iron, such as copperas, and give a black color; but if a persalt of iron be used, the resulting color is a gray slate. The former becomes darker as it stands, the latter grayer; but the theory of these actions and reactions we must pass for the present. When we take the goods rendered black by the protosalt, and put them through lime water, they are converted into a rich brown from the peroxidizing of the iron; but, if allowed to stand exposed to the air for a short time, they assume their black color again. If the goods are put into the logwood when they are of this brown color, the black is seldom good.† They should always to be allowed to assume the black hue before being immersed in the logwood bath. For this reason we have always preferred washing them from the copperas rather than putting them through lime water.

The general iron mordant for wood dyes is the acetate of iron (iron liquor), or what is most commonly used now, the pyrolignite of iron.‡ The acetate of iron may be prepared

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* See chapter IX., of this Part, article *Processes of Dyeing Black.*

† These subjects are fully discussed, practically, in chapter III., Part I., article *Logwood*, and chapter II., Part III., article *Purity of Water.*

‡ Mr. John D. Prince, of Lowell, Massachusetts, obtained a patent, in this country, on the 24th of April, 1841, for what he calls "A new mode of producing Black Color in Dyeing." We make the following extract from the specification of this patent:—"I have ascertained by repeated trials, that the protosulphate of iron (copperas) may be advantageously substituted for the acetate of iron, as a mordant, by bringing it into that state which shall coerce it to deposit these two ingredients, the protoxide and peroxide of iron, on the goods under treatment. There are various articles which effect this purpose to a certain extent, but that which I found to do so in the most perfect manner, is the arsenious acid (arsenic) mixed, or combined, with the protosulphate. The proportions of the two ingredients admit of considerable latitude, but the following has been found to answer well:—I dissolve

by mixing together acetate of lead and protosulphate of iron. The sulphate of lead is formed and falls to the bottom; the acetate of iron remains in solution, but it is commonly prepared by throwing pieces of iron into the acid, which dissolves it. The pyrolignite of iron is in general preferable. It is prepared by allowing iron to steep in pyroligneous acid (impure acetic acid) for several weeks. As this acid contains a quantity of pyrogeneous oils and other impurities, it preserves the iron for a longer time in the state of a protoxide than almost any other solvent available in the arts; hence the decided preference given to this by practical men. We shall often have occasion to refer to this subject, *as it is one which is too much neglected*, and which produces many serious evils. It may, however, be in the meantime observed that pyrolignite of iron, used instead of copperas in dyeing black, gives a preferable shade of color.

Persalts of iron are mostly used for dyeing Prussian blue.

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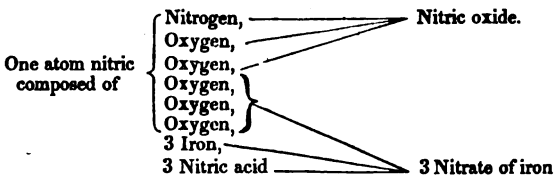
one pound of copperas in a gallon of water, and in another gallon of water I dissolve four ounces of white arsenic, and then mix the two solutions, which mixture constitutes my iron liquor. For transportation it is desirable to obtain the ingredients from which the solution is to be made, in a dry state; for this purpose I take copperas and drive off its water of crystalization by exposing it to heat upon iron, or in any other convenient mode, and to the dried mass I add four ounces of white arsenic for every pound of copperas first taken, the whole is then reduced to powder, and may be readily converted into iron liquor by adding the proper quantity of water. The tendency of the protoxide, in copperas, is to pass too rapidly and completely into the state of peroxide, by which the object of obtaining a good black color is defeated, an injurious brown tint being produced. The arsenious acid has the property of preventing the peroxidation, and of inducing that state of mixed oxide upon which the perfection of the black is dependent, and this combination of arsenious acid, and its application to the purpose of producing a black color are, as I believe, *entirely new*." Superior methods might be had recourse to for effecting the same purpose; and, indeed, common humanity would dictate the complete abandonment of the process just described, as the handling of goods dyed with such a decoction as that above referred to, cannot but prove detrimental, not only to the health of the dyer, but also to the wearer. This fact ought to stimulate to further improvements in dyeing processes; and we think much might to this end be effected by holding out moderate premiums, though we are sorry to say, that instead of receiving a premium, the workman is too often robbed of the honor of improvements which he does effect. The constant jealousy which exists amongst employers, will, we fear, prevent their joining together for the improvement of the general trade.

Many attempts have been made to dye black by merely impregnating the goods with peroxide of iron, and immersing them into a decoction of logwood, to save all the routine of steeping, washing, and dipping of the ordinary black, but it has never succeeded. A very good black is obtainable when newly dyed, but very soon changes into brown.

The principal persalt of iron used is the nitrate. This is made by putting clean iron into nitric acid, by which it is very quickly dissolved. The iron should be added as long as the acid continues to dissolve it; but cautiously, otherwise the action will be so violent as to cause it to boil over. While engaged in this process, care should be taken not to breathe any of the fumes which come off, as they are very destructive of health. The reaction which takes place between the acid and the iron may be thus expressed:—The nitric acid is composed of five atoms oxygen, and one nitrogen; every fourth atom of nitric acid in the solution is decomposed to give oxygen to the iron, so that the remaining three atoms of nitric acid may combine with it; better shown in the following diagram:—



The nitric oxide is the gas which flies off; but its attraction for oxygen is so great, that, the moment it is liberated from the solution, it combines with oxygen from the air, and is converted into nitrous acid gas, the well known red fumes which always fly off when metals are dissolved in this acid.

The nitrate of iron alone dyes a buff or nankeen, which is probably the easiest dyed color that we have, *as it is only necessary to put a little of the nitrate of iron into water, and immerse the goods.* The particular use of this salt is for *Prussian blue.** The goods are first dyed buff by this

* See chapter V. Part III., article *Prussiate of Potash*, and chapter III. Part V., article *Prussian Blue.*

salt of iron, then thoroughly washed, and put into a very dilute solution of ferroprussiate of potash,—made acid by a few drops of sulphuric acid; they are washed from this in clean water, to which a little alum has been added. We have known many attempts made to substitute copperas for nitrate of iron for dyeing Prussian blue, but need hardly say they were unsuccessful. A very little knowledge of the nature of these salts would have told the experimenters that protosalts of iron give only a grayish color with yellow prussiate of potash; but, if red prussiate of potash was used, copperas would be a better mordant than nitrare of iron, as it gives a dark blue with the protosalts, and only a greenish gray with the persalts of iron.*

Mercer's Assistant Mordant.—Mr. John Barnes of Church, chemist, and Mr. John Mercer of Oakenshaw, calico-printer, obtained a patent, in November, 1842, "for certain improvements in the manufacture of articles used in printing and dyeing cotton, silk, woolen, and other fibres." These improvements consist in the production of a new material, termed by the patentees "*Assistant Mordant Liquor*," which, when combined in certain proportions with the ordinary mordants, renders them more effective and useful, thereby improving the manufacture of such articles. The manner in which the improvements are carried into effect is as follows:—To 100 lbs. avoirdupois of potato starch, add 37½ gallons of water, 12½ gallons of nitric acid of commerce (specific gravity 1·300), and four ounces avoirdupois of oxide of manganese. The chemical action which takes place among these ingredients is allowed to proceed until the nitric acid is destroyed. To the residuum thus produced, add fifty gallons of pyrolignic acid, and the compound is the assistant mordant liquor, in a fit state to add to the various mordants used in printing and dyeing. The proportion in which the assistant mordant liquor must be added, to produce the various improved mordants, will vary according to the chemical properties and nature of the mordant to which it is applied; but,

* See *Köber's Mordant for Wool*, chapter IV. Part IV.

by experience, the following proportions have been found to produce a greatly improved article:—For black, take one gallon of iron liquor (pyrolignate of iron, well known in the arts), one gallon of assistant mordant liquor, and one gallon of water, either thickened or not, according to the mode in which it is to be applied. For purple, take one gallon of iron liquor, two gallons of assistant mordant liquor, and six gallons of water. For paler purple, one gallon of iron liquor, three gallons of assistant mordant liquor, and twelve gallons of water; and for still paler purple, one gallon of iron liquor, four gallons of assistant mordant liquor, and from twenty to thirty gallons of water. These improved articles or mordants, are applied, washed, and dyed in the usual way. For tin or aluminous mordants, the same rule is followed; excepting that red liquor, or other salts of alum, or muriate of tin, or other salts of tin, are used, instead of iron liquor, or other salts of iron. For dyeing silk or woolen, the assistant mordant liquor is added to the tin, iron, or aluminous mordant, either with or without coloring matter, in the same boiler; but this, and other practical arrangements, must depend on the judgment and skill of the operator.

We have now briefly noticed the three principal mordants, namely, ALUMINA, TIN, and IRON. There are others which, strictly speaking, may be ranked as mordants, such as lead, copper, zinc, manganese, &c.; but these having a more limited application, we will prefer noticing them as we detail the method of dyeing the several colors for which they are used.—(See Appendix, article *Mordants*.)

UNION OF COTTON WITH COLORING MATTER.—The effect of porous bodies in combination and decomposition, *independently of chemical affinity*, has of late years, occupied considerable attention; and as the subject is one of great interest in this place, we cannot, it appears to us, more appropriately conclude this chapter, than by noticing a few of the theories promulgated by the different authors who have investigated the subject.

If we examine, says Professor Mitscherlich, a piece of box-wood by the microscope, we find it composed of cells

which have a diameter of about $\frac{1}{1400}$th of an inch. Heated to redness, the form of these cells suffers no change, for the particles of which it is composed have no tendency to run together in fusion. A cubic inch of box-wood charcoal boiled for some time in water, absorbed five-eighths of its volume of that liquid; from which, and other data, it was computed that the surface of its pores was 73 square feet.

Saussure observed that a cubic inch of box-wood charcoal absorbed 35 cubic inches of carbonic acid; and as the solid part of the charcoal formed three-eighths of its bulk, these 35 inches of gas must have been condensed into five-eighths of an inch, or 56 cubic inches into one, under the ordinary pressure of the atmosphere. But carbonic acid liquifies under a pressure of 36·7 atmospheres, and, therefore, with a power of condensation equal to 56 atmospheres, which the charcoal exerted in Saussure's experiment, at least one-third of the gas must have assumed the liquid state within its pores.

Every other porous body has the same property as charcoal. Raw silk, linen, thread, the dried woods of hazel and mulberry, though they condense but a small quantity of carbonic acid, take up from 70 to 100 times their bulk of ammoniacal gas; and Saxon hydrophane, which is nearly pure silicia, absorbs 64 times its bulk. The gases enter into no combination with the solid which absorbs them, for the air-pump alone destroys their union.

The manner in which gases are attracted to the surfaces of solid bodies is very much like that which these exert on substances dissolved in water. The charcoal of bones has been long employed to remove coloring matter from the brown solution of tartaric acid, from syrup in the refining of sugar, and from a variety of other liquids containing organic substances; and it is found that the coloring matter so attracted remains attached to the surface of the charcoal without effecting any change upon it. In this animal charcoal the carbon is mixed with ten times its weight of phosphate of lime, and if that be washed away by an acid, the remaining charcoal has nearly twice

the decolorating power of an equal weight of ivory-black. Bussy, who has made the action of these charcoals the subject of particular investigation, informs us, that if ivory-black, after the extraction of its earth of bones by an acid, be calcined along with potash, and the potash be afterwards washed out, or if blood be at once calcined with carbonate of potash and washed, the remaining charcoal has the power of decolorating twenty times as much syrup as could be done by the original bone charcoal. Animal charcoal removes, also, lime from lime water, iodine from a solution of iodide of potassium, and metallic oxides from their solutions in ammonia and caustic potash.

A satisfactory explanation of these remarkable facts has yet to be sought for. Mitscherlich calls the force which produces them an action of contact, or attraction, of surface; and he calculates, as we have seen, the extent of surface in proportion to the mass as the measure of the force which it exerts. On the other hand, Saussure in his invaluable paper on the absorption of gases, informs us that charcoal from box-wood, in the solid state, absorbs twice as much common air as when it is reduced to powder. Now the effect of pulverization is certainly not to diminish the extent of surface. Saussure accounts for it in another way, and his explanation seems to connect many of the facts. The condensation of gases in solid charcoal goes on, he conceives, in the narrow cells of which it is composed, and is analogous to the rise of liquids in capillary tubes. In both, he says, the power appears to be in the inverse ratio of the size of the interior diameters of the pores, or tubes, of the absorbing bodies. When we pulverize a body containing such cells, we widen, open, and destroy them. Fir charcoal, whose cells are wide, absorbs 4½ times its bulk of common air, and box-wood charcoal with smaller pores takes 7½. Charcoal from cork, with a specific gravity of only 0·1, absorbs no appreciable quantity. From this it would appear that many of the operations of dyeing depend upon this influence of the surface, or the capillary action described by Saussure.

The microscopic examination of the fibres of cotton shows them to consist of transparent glassy tubes, which, when unripe, are cylindrical, and in the mature state collapsed in the middle, from end to end, giving the appearance of a separate tube on each side of the flattened fibre. In many of the operations of dyeing and calico-printing, the mineral basis of the color is applied to the cotton in a state of solution in a volatile acid. This solution is allowed to dry upon the cloth, and in a short time the salt is decomposed, just as it would be in similar circumstances without the intervention of cotton. During the decomposition of this salt its acid escapes, and the metallic oxide adheres to the fibre so firmly as to resist the action of water applied to it with some violence. In this way does acetate of alumina act, and nearly in the same manner acetate of iron. The action here can only be mechanical on the part of the cotton, and the adherence, as will be shown, confined to the interior of the tubes of which wool consists. The metallic oxide permeates these tubes in a state of solution, and it is only when its salt is there decomposed, and the oxide precipitated and reduced to an insoluble powder, that it is prevented from returning through the fine filter in which it is then inclosed.

When a piece of cotton, which, in this view, consists of bags lined inside with a metallic oxide, is subsequently dyed with madder, or log-wood, and becomes thereby red, or black, the action is purely one of chemical attraction between the mineral in the cloth, and the organic matter in the dye vessel, which together form the red or black compound that results; and there is no peculiarity of a chemical nature from the mineral constituent being previously connected with the cotton. The process of cleansing in boiling liquids, and in the wash-wheel, to which cotton printed with the various mordants is subjected, previous to being maddered, is to remove those portions of metallic oxide which have been left outside the fibres, or got entangled between them, and fastened there, more or less firmly, by the mucilage employed to thicken the solution.

The view which has now been given, is in some respects,

the old mechanical theory of dyeing held by Macquer, Hellot, and Le Pileur d'Apligny before the time of Bergman. Although unacquainted with the microscopic appearance of cotton, d'Apligny argued that as no vegetable substance in its growth can receive a juice without vessels proper for its circulation so the fibres of cotton must be hollow within. And of wool, he says, the sides of the tubes must be sieves throughout their length, with an infinity of lateral pores. We may gather also that he conceived dyeing to consist, first, in removing a medullary substance contained in the pores of the wool, and afterwards depositing in them particles of a foreign coloring matter. But Bergman, in his Treatise on Indigo, in 1776, *upset all this*, and attributed to cotton a power of elective attraction, by which all the phenomena of dyeing were referred to purely chemical principles.

"Macquer" says Mr. Crum, "soon adopted the chemical theory, and it was keenly advanced by Berthollet, who succeeded Dufay, Hellot, and Macquer, in the administration of the arts connected with chemistry. Berthollet has been followed by all who have since that time written on the subject, but nothing like evidence has ever been produced; and if we only consider that chemical attraction necessarily involves combination, atom to atom, and, consequently, disorganization of all vegetable structure; that cotton wool may be dyed without injury to its fibre, and that that fibre remains entire, when, by chemical means, its color has again been removed, we shall find that the *union of cotton with coloring matter must be accounted for otherwise than by chemical affinity.* In particular processes, as we shall see, attraction is no doubt exerted; *but it is an attraction connected with structure, and, therefore, more mechanical than chemical.*

"When we examine with a powerful microscope a fibre of cotton, dyed either with indigo, with oxide of iron, chromate of lead, or the common madder-red, the color appears to be spread so uniformly over the whole fibre that we cannot decide whether the walls of the tube are dyed throughout, or that the coloring matter only lines their internal surface. But the microscope shows that the collapse which occurs in raw

and bleached cotton is very considerably diminished in the dyed. The greater number of specimens of Turkey-red which I have examined, show the same uniformity of color; but in others of them, little oblong balls appear all along the inside of the tube, of the fine pink shade of that dye, while the tube itself is colorless. It is in stout cloth dyed in the piece that these rounded masses occur.

"We have moreover the powerful analogy of the arrangement of coloring matter in plants, in support of this view of the case.* 'Cellular tissue,' says Dr. Lindley, in his Introduction to Botany, 'generally consists of little bladders, or vesicles, of various figures adhering together in masses. It is transparent, and, in most cases, colorless; when it appears otherwise its color is caused by matter contained within it.' * * * * 'The bladders of cellular tissue are destitute of all perforations, so far as we can see, although, as they have the power of filtering liquids with rapidity, it is certain that they must abound in invisible pores.' * * 'The brilliant colors of vegetable matters, the white, blue, yellow, scarlet, and other hues of the corolla, and the green of the bark and leaves, is not owing to any difference in the color of the cells, but to the coloring matter of different kinds which they contain. In the stem of the garden balsam, a single cell is frequently red in the midst of others which are colorless. Examine the red bladder, and you will find it filled with a coloring matter of which the rest are destitute. The bright satiny appearance of many richly colored flowers depends upon the colorless quality of the tissue. Thus in *Thysanotus fascicularis*, the flowers of which are of a deep brilliant violet, with a remarkably satiny lustre, that appearance will be found to arise from each particular cell containing a single drop of coloring fluid, which gleams through the white shining membrane of the tissue, and produces the flickering lustre that is perceived.' Cotton is itself cellular tissue, and

* See chapter II, Part I., and Appendix, articles *Color; its influence on Odors*, and *Experiments and Observations on Light*.

the ligneous basis of all the forms of these vessels has the same chemical constitution."

Another class of processes in dyeing have been alluded to, in which the action more resembles chemical affinity. By which was meant that in which pure cotton, by mere immersion in different liquids, withdraws a variety of substances from their solution. The "indigo vat" is a transparent solution, of a brownish yellow color, consisting of deoxidized indigo combined with lime, and containing seldom more than $\frac{1}{500}$th of its weight of coloring matter.* By merely dipping cotton in this liquid, the indigo attaches itself to it in the yellow state, in quantity proportioned within certain limits to the length of the immersion, and all that is then necessary to render it blue is to expose it to the air. "Here," says Mr. Crum, "an inactive spongy substance exercises a power which overcomes chemical affinity, but the mixture, which is formed of cotton and indigo, possesses none of the characters of a chemical compound. We can only recognize, in this action, the same force, whatever that may be, which enables animal charcoal to decolorate similar liquids. Charcoal, as we have also seen, withdraws metallic oxides from their solution in alkalies. Cotton wool has the same power, and it is extensively used as a means of dyeing with the yellow and red chromates of lead. If lime in excess be added to sugar of lead, dissolved in a considerable quantity of water, the lead which precipitates is redissolved in the lime water, and forms a weak solution of plumbate of lime. If a piece of cotton be immersed in this solution it appropriates the lead, and when afterwards washed, and dipped in a solution of chrome, the lead becomes chromate of lead.

"The same force enables cotton to imbibe basic salts of iron and tin by immersion in certain solutions of these metals; and many other examples of what Berzelius calls a cytalytic force, in decomposing weak combinations, will occur to those who are familiar with the art of dyeing. It is interesting to

* See chapter V., Part III.; see also chapter III., Part I., article *Indigo*, and chapter III., Part. IV.

compare the amount of surface exposed by cotton wool, with that of the more minute divisions of charcoal." Professor Balfour, who has measured with great care the fibres of various qualities of wool, says, that the fibre of New Orleans wool varies most commonly from $\frac{1}{1500}$th to $\frac{2}{3000}$th of an inch in diameter. About forty of these fibres, or tubes, compose a thread of No. 38 yarn, (thirty-eight hanks to the pound.) Ordinary printing-cloth has, in the bleached state, 493 lineal feet of fibre, or 10·6 square inches of external surface of fibre in a square inch, which weighs nearly one grain. It is easy to compress 210 folds of this cloth into the thickness of one inch. It has then a specific gravity of 0·8. One cubic inch has 94·163 lineal feet of tube, and 16·8 feet of external surface; or, if we include the internal surface, there are upwards of 30 square feet of surface of fibre in one cubic inch of compressed calico. The charcoal of box-wood has, as we have seen, 73 square feet of surface to the inch, with a specific gravity of 0·6.

CHAPTER II.

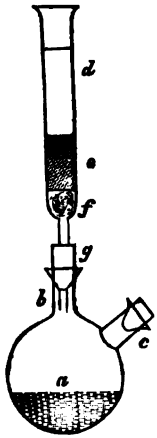
Tannin and Gallic Acid—Purity of Water—Chemical knowledge indispensable to the Dyer—Construction of Dye-house.

TANNIN AND GALLIC ACID.—Upon a certain species of oak, the *quercus infectoria*, there grow excrescences, which originate in punctures produced by the *cynips* (gall-wasp), for the purpose of depositing her eggs. A kind of juice exudes from these punctures, and gradually forms round these ova hard round bodies, varying in size from one-fourth of an inch to a whole inch in diameter. These substances, from their resemblance to nuts, and from their bitter taste, are called gall-nuts. By the repeated experiments of many excellent chemists upon this substance, it is considered to contain two peculiar principles. One of these, a crystalizable substance, is obtained from a macerated solution of galls, after standing in the air for a long time. This, from its possessing many acid properties, is termed gallic acid. The other being that substance which combines with skins, during the process of tanning, changing them into leather, is termed tannin, or, from its having some acid properties, tannic acid.

From these two substances being always found associated together in one vegetable, it was thought probable that the one might give rise to the formation of the other. This supposition has been recently verified by M. Pelouze, an eminent French chemist; who, by the following exceedingly simple process, extracted tannin from galls in a state of purity:—

To the vessel represented in *fig*. 18 is fitted, by means of a cork *g*, a funnel-shaped tube. The neck *c* is to be kept corked, air-tight, during the process. At the bottom of the tube is placed a little clean cotton, as shown at *f*. Above this cotton is placed a quantity of nut-galls in fine powder, as shown at *e*. Over this is poured a quantity of common

Fig. 18.



sulphuric ether, sufficient to fill the rest of the tube as seen at *d*. A cork is then fitted tightly in the opening at the top of the tube, and the whole set aside. Next day two layers of liquor are found in the vessel *a*, one very light and liquid, occupying the upper part, the other having a light amber color, and the appearance of a syrup, occupying the lower part. These liquids being poured into a tube of the shape represented in *fig*. 19, stopping the bottom with the finger, after remaining at rest for a few minutes, the liquids again separate; the heavy liquid being then allowed to fall out into a capsule, and the light retained, this last may be distilled for the sake of recovering the ether. The dense liquid which is in the capsule is next to be washed two or three times with sulphuric ether, and afterwards dried in a stove, or by very gentle heat; the matter left has a spongy appearance, very brilliant, and generally of a light yellow tint. This is tannin in a state of purity. By this process, from 35 to 40 per cent. can be extracted from nutgalls.

M. Pelouze found that if a solution of tannin be kept closely corked from the atmosphere, no change takes place; but if left in contact with oxygen, the tannin undergoes a change, and gallic acid is formed. Hence he concludes that gallic acid does not exist except in very minute quantity in vegetables, and that the error of supposing that these two acids existed together in vegetables, arose from the method adopted to procure gallic acid, which was by allowing the macerated vegetable matter to stand in contact with the air, till the gallic acid crystalized from the solution, this being nothing more than a process for converting tannin into gallic acid by the absorption of oxygen.*

* M. Le Roger recommends the following process for obtaining gallic acid:—

After having exhausted gall-nuts by repeated decoctions, add to those decoctions, concentrated, a solution of gelatine, which precipitates the tannin: filter the

Fig. 19.

This discovery is of great importance to the dyer, as it points out the evil of allowing liquids which contain tannin, to stand exposed to the air for any considerable length of time; for although gallic acid acts in a somewhat similar manner with metallic oxides as tannic acid, yet the gallates are much more fugitive than the tannates. For example, if we precipitate tannic acid and gallic acid by a persulphate of iron, they are both dark blue, bordering on black; excepting a slight change of shade, the tannate remains permanent; but if the gallate be allowed to stand a few hours, it is dissolved in the supernatant liquid, and becomes almost colorless; the sulphuric acid resumes its attraction for the iron, and crystalizes as a protosulphate (copperas) and the gallic acid is partly decomposed, and partly crystalized. These changes take place in a few minutes, if the liquor containing the precipitate be boiled. Now, if galls, or what is now more commonly used instead, sumac, be allowed to stand till after fermentation takes place, which is very soon, a great portion of the tannin is converted into gallic acid; and although the cloth dyed in sumac that is thus altered, should be, as some dyers affirm, equally dark, it will not be equally fast; but from personal experience, it is neither equally dark nor equally beautiful. It cannot be so dark, for gallic acid being much more insoluble than tannin, falls to the bottom whenever it is formed, and consequently leaves the supernatant liquid much weaker in its dyeing properties.

More recent discoveries have shown that tannin is convertible into gallic acid, by other and much more rapid means than being left to absorb oxygen; these are by the

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liquid, add very pure animal charcoal, and boil for eight or ten minutes; then filter it again, and by evaporation and cooling, silky and perfectly white crystals of gallic acid are obtained. Gall-nuts of the first quality afford, by this process, a quarter of their weight of acid.

common processes of inducing fermentation. It is well known that fermentation is simply a derangement of the elements of certain complex compounds, and the arrangement of these elements in different positions and proportions, giving rise to new and altogether different compounds of a more simple nature, that is, having a smaller number of elements. The primary compounds are formed under the unknown influence of the vital principle; but whenever this principle is withdrawn, they seem but passively to retain their chemical conditions.* The attraction of their elements seems too weak to enable them to resist any marked change of circumstances. Even a slight elevation of temperature is sufficient to overpower their affinities and induce change. As in the case of fermentation, if they are brought into contact with a body which is in the act of derangement, that body excites the same derangement in them, and the equilibrium being disturbed, the elements are left to arrange themselves according to their different attractions. If, for example, we dissolve a little sugar of grapes, which is composed of 12 carbon, 12 hydrogen, and 12 oxygen, in a little water, and raise the solution to a temperature of about 80° Fah.; and if to this we add a little yeast, which is a substance whose atoms are in the act of transposition; the yeast does not combine chemically with the sugar, but it communicates to it by contact the action of transposition, and thereby deranges the classification which the atoms had assumed to form sugar; and the atomic elements being thus set at liberty, begin to arrange themselves differently: every three atoms of the hydrogen combine with two of the carbon and one of the oxygen, forming four atoms of alcohol. The remaining eight atoms of oxygen unite with the remaining four of carbon in the relation of one to two, forming four atoms of carbonic acid gas. Thus the whole sugar is converted into two different substances, of which the yeast forms no part. It only acts the part of a bold revolutionizer, breaking up existing compositions, that new ones may be formed

* See Appendix, article *Fermentation*.

from their elements. Now tannin is found to undergo the same sort of change as the sugar, when brought into contact with certain substances: and one of the new compounds formed from this transposition, is gallic acid. M. Antoine has indeed directly shown, *that a very small quantity of nutgalls is capable of converting a large quantity of tannin into gallic acid.* The following are some of the experiments which he made to ascertain under what influence this change is operated. "I used," he says, "nutgalls exhausted by ether as a ferment, and this I put in contact with the solution of tannin, which served as a liquor of comparison, or type liquor.

"On the 27th of August, 1840, I took 10 grs. of nutgalls exhausted by ether, 5 grs. of tannin, and 110 grs. of water; the type liquor consisted of 110 grs. of water. and 5 grs. of tannin. I kept these liquors in flasks covered with paper, and perforated with holes, until the 21st of September; and as I then wished to ascertain the state of the liquors, I took one grain of each, and added an excess of sulphate of quinine,* (a substance which precipitates tannin). I obtained no precipitate from that containing the nutgalls, the type liquor, on the contrary, gave an abundant precipitate. I did not expect so good a result. I multiplied my experiments, and as the following corroborate the preceding, it will be seen that a small quantity of nutgalls is capable of converting 15 grs. of tannin into gallic acid.

"On the 23d of September, I put into a wide-mouthed

* An alkaline base obtained from yellow bark; the *Cinchona cordifolia.* This substance, combined with sulphuric acid, forms the *sulphate of quinia*, which is now so extensively used as a medicine, and as a substitute for the various forms of Peruvian bark. To obtain quinia, bruised yellow bark is boiled in repeated portions of water, acidulated by sulphuric acid, till all its soluble matters are extracted; a little excess of quicklime is then added to the strained decoction, and the precipitate which is formed is collected, washed, and carefully dried; it is then digested in alcohol, which takes up the quinia, and from which it may be obtained in the form of a yellowish uncrystalizable substance by careful evaporation. It is dissolved in dilute sulphuric acid, and the sulphate of quinine, or quinia, crystalizes from its concentrated solution in fine silky prisms, which effloresce on exposure to air. Sulphate of quinia is barely soluble in water, and intensely bitter. It is administered as a tonic and febrifuge in doses of from one to five or six grains.

flask 5 grs. of tannin, 5 of nutgalls exhausted by ether, and 100 grs. of distilled water, and I exposed it to the air until the 7th of November. Into a second flask, to the same quantity of water and nutgalls, I added 8 grs. of tannin, and to a third, 15 grs. of tannin. On the 7th of November, I precipitated the tannin from 5 grs. of each of these liquors, and I obtained exactly the same weight of tannate of quinine from each. These experiments appeared to me very curious, inasmuch as even 15 grs. of tannin under the influence of 5 grs. of nutgalls, exhausted by ether, convert in a very short time as large a quantity of tannin. Finally, two other experiments made with 5 grs. of tannin, 128 grs. of water, and 5 grs. of nutgalls exhausted by ether, gave me, after a contact of a month, $\frac{1}{12}$ gr. of tannate of quinine, whilst two other liquors prepared with the same proportions of water and tannin without any nutgalls, yielded $\frac{3}{16}$ gr. of that salt. These four liquors were prepared in the same day, and were exposed to the same influences."

This author also shows that galls have the same property as yeast in exciting fermentation in sugar for the production of alcohol, thereby proving, should additional proof be wanting, that galls contain within themselves a substance capable of producing fermentation and converting tannin into gallic acid. Now, just in proportion as gallic acid is inferior to tannin in its dyeing properties, will be the extent of the evil of allowing liquors which contain tannin, and which depend upon it for their dyeing properties, to stand till fermentation begins. In some liquors this commences in the course of three or four days; much, however, depends upon the temperature.

But it may be asked, that although galls possess within them the property of a ferment; does sumac, *which has in many operations superseded the use of galls*, possess the same property? Whether sumac possesses the property of exciting fermentation in other substances, has not yet been determined; but from a number of experiments upon the action of various substances upon tannin, it would seem either to induce or facilitate fermentation; and further

we venture to say that the tannin in sumac is more readily converted into gallic acid than the tannin of gall-nuts. If the liquor of galls be allowed to stand exposed to the air, it requires a considerable time before its tannin is converted into gallic acid, but there are a number of substances which, if put into it, causes the formation of gallic acid to proceed much more quickly. Amongst others, the tartaric and malic acids possess this property in a high degree.* Now, sumac according to some recent analysis contains a great quantity of malic acid, which, were we allowed to reason from analogy in chemical science, places it under very favorable circumstances for fermentation. Indeed in certain seasons of the year, we have known it to ferment in forty-eight hours. Whether this fermentation was induced first by the tannin or the coloring matter which it contains—for sumac contains a distinct coloring matter—we cannot determine. A very short time however makes it lose its coloring property, but as we shall see in the next paragraph, the addition of certain acids has the same effect upon this coloring matter, so that the *losing of color may be the effect of acids formed in the liquor, as well as the immediate effect of fermentation.*

It may also be asked, seeing that the introduction of certain substances facilitates fermentation, is there no substance which can be introduced without destroying the dyeing properties of the substance which can prevent fermentation. The answer to this may be given in the language and experiments of the author last quoted, M. Antoine, "I made," he says, "some new experiments to ascertain the action of certain other agents on gallic fermentation. With the following liquids prepared in the same proportions (110 of water, and 20 of nutgalls both by weight), and to which I had added to the first 20 drops of pyroligneous acid (red liquor), to the second 12 drops of sulphuric acid (vitriol), to the third 12 drops of nitric acid (aquafortis), and to the fourth 12 drops of hydrochloric acid (spirit of salt). I obtained

* See chapter V., Part I., articles *Tartaric* and *Malic Acid.*

the following results, precipitating the tannin by sulphate of quinine:—

Type liquor gave .	0·60	centigrammes
Pyroligneous acid . .	0·35	"
Sulphuric . . .	0·59	"
Nitric	0·55	"
Hydrochloric . .	0·50	"

"These results appeared to me to be very curious. Indeed where no agent could modify the progress of the phenomenon, the tannin was almost entirely converted into gallic acid, whilst in the liquors containing the above-mentioned bodies, the progress of fermentation is arrested, and very little gallic acid formed."

Although these results are very curious as regards certain chemical phenomena, the use of these acids as preventatives to fermentation is not advisable in a practical point of view, except when the sumac (for the remarks refer mutually to sumac and galls) is to be kept for a long time, and a possibility of using it for *light* shades; for *dark* grounds, sumac with acid, does not give the same depth of shade, and as the goods require to be washed when the acid is used, previous to putting them into the iron, there is a waste of time without an equivalent advantage. But with light shades such as drabs, grays, &c., the addition of a little sulphuric acid to the sumac, makes a superior and uniform color. When we say superior color, we do not mean the yellow coloring matter which new boiled sumac possesses, for sulphuric acid destroys the color. If pure white cloth be put through sumac at a temperature of 140°, light straw or lint color is produced; but if sulphuric acid be put in with the sumac, the color on the cloth is inappreciable. When the goods are washed from this, and put through a very weak solution of sulphate of iron (copperas) the color which is produced is much sweeter, appearing fully and evenly combined with the fabric. When no acid is used, as is frequently the case, the color often appears in grains upon the surface of the cloth. When sumac

or galls are used, it is best for all purposes that they be fresh, and newly boiled or macerated.

The following table abridged from Brande's Manual of Chemistry, will give an idea of the action of some metallic salts upon a solution of galls or sumac.

NAMES OF SALTS USED.	COLOR OF PRECIPITATES.
Protochloride of manganese, . .	dirty yellow.
Protosulphate of iron, (copperas) .	purple tint.
Persulphate of iron, ...	black.
Chloride of zinc, (muriate of zinc) .	dirty yellow.
Protochloride of tin, ...	straw color.
Perchloride of tin, ...	fawn color.
Sulphate of copper, (blue stone) .	yellow brown
Nitrate of copper, ...	grass green.
Nitrate of lead, ...	dingy yellow.
Tartrate of antimony and potash, .	straw color.
Tartrate of bismuth and potash, .	copious yellow or orange.
Sulphate of uranium, ...	blue black.
Sulphate of nickel, ...	green.
Protonitrate of mercury, . .	yellow.

In attempting to draw a practical inference from some of these results, we would for example conclude that persulphate of iron is much better adapted for dyeing blacks than protosulphate, as the former is mentioned as producing a deep black, while the latter gives only a purple tint. It is much to be regretted that in making out these tables, *care is not taken to give the results in all their bearings.* In the forms in which we meet them in chemical books, if they do not tend to lead practical men astray, *they at least give a lower idea of the labors of scientific chemists.* The results of the two salts mentioned are correct, looking at the results the instant the mixtures are made; but in the course of twenty minutes the black from the persulphate becomes a brownish slate, whereas the purple tint of the protosulphate changes during the same time to a deep black; and these changes continue till the former has become a light yellowish slate, and the latter a perfect ink black.

When trying the difference of effect produced by the persulphate and protosulphate of iron upon pure tannin and gallic acid, it may further be observed, that the changes pro-

duced by tannin are somewhat similar to those which occur in a solution of galls. With gallic acid the persulphate gives at first a black precipitate, not so dark as the tannate, but in a few minutes it changes to an olive, and continues changing till it becomes almost colorless. With the protosulphate, at first the color is scarcely visible, but after a few hours' exposure, it assumes a rich violet. From these facts, it may be concluded, *that tannin is much superior to gallic acid as a dyeing agent for black; besides, it is more insoluble.*

The following TABLE, from Ure's Dictionary of Arts, &c. shows the quantity of extractive matter and tan in 100 parts of the several substances:—

Substances.	In 480, by Davy.	In about 8 ounces, by Biggins.	In 100 parts, by Cadet de Gassincourt.	Substances.	In 480, by Davy.	In about 8 ounces, by Biggins.	In 100 parts, by Cadet de Gassincourt.
White inner bark of old oak	72	-	21	Bark of Cherry-tree	—	59	24
Do. young oak	77			Do. Sallow	—	59	
Do. Spanish chestnut	63	30		Do. Poplar	—	76	
Do. Leicester willow	79			Do. Hazel	—	79	
Colored or middle bark of oak	19			Do. Ash	—	82	
Do. Spanish chestnut	14			Do. trunk of Spanish chestnut	—	98	
Do. Leicester willow	16			Do. Smooth oak	—	104	
Entire bark of oak	29			Do. Oak, cut in spring	—	108	
Do. Spanish chestnut	21			Root of Tormentil	—	-	46
Do. Leicester willow	33	109		Cornus sanguinea of Canada	—	-	44
Do. Elm	13	98		Bark of Alder	—	-	36
Do. Common willow	11	boughs, 31		Do. Apricot	—	-	32
Sicilian sumac	78	158		Do. Pomegranate	—	-	32
Malaga sumac	79			Do. Cornish cherry-tree	—	-	19
Souchong tea	48			Do. Weeping willow	—	-	16
Green tea	41			Do. Bohemian olive	—	-	14
Bombay catechue	261			Do. Tan shrub with myrtle leaves	—	-	13
Bengal catechue	231			Do. Virginian sumac	—	-	10
Nut-galls	127	-	46	Do. Green oak	—	-	10
Bark of oak, cut in winter	—	30		Do. Service-tree	—	-	8
Do. Beech	—	31		Do. Rose chestnut of America	—	-	8
Do. Elder	—	41		Do. Rose chestnut	—	-	6
Do. Plum-tree	—	58		Do. Rose chestnut of Carolina	—	-	6
Bark of the trunk of willow	—	58		Do. Sumac of Carolina	—	-	5
Do. Sycamore	—	53	16				
Bark of Birch	—	54					

PURITY OF WATER.—Another thing which modifies the results of the foregoing experiments, in their application to dyeing, is the quality of the water used. If the experiments be performed with distilled water, it will be found on repeating them with common spring water, that *one half* of the quantity of stuffs will give the same depth of color; and

that the colors, in this instance, have more of a purple hue, and are more permanent. This may be illustrated by the following very simple experiment:—

Thus, take two glass jars of equal size, fill them half full with distilled water, and add an equal quantity of a solution of galls, or sumac; put into each an equal number of drops of a solution of protosulphate of iron (copperas); the change of color is scarcely perceptible. But fill up one to the brim with spring water, and it almost instantly becomes a dark reddish black. Allow both jars to stand for an hour, the solution with the distilled water will have become a deep violet, while the other, notwithstanding the double quantity of water, is so dark that no light is transmitted; and it will require one-half more water to reduce it to the same shade as the other, but still retaining more of the reddish hue—which, by the way, makes it superior for black. It will also be found to be more insoluble, and requiring a greater proportion of acid to decompose it.

If soft, or filtered river water, be used instead of distilled water, the distinction is not so great, but still the difference is equal to *one half*. The best water which the writer has experienced for dyeing black, and other *saddened colors*,* gave by qualitative analysis, the following results:—

Carbonic acid, lime, silica, iron, sulphuric acid, and muriatic acid.

The whole solid contents did not exceed one grain in a fluid ounce. These ingredients probably existed in the water as sulphate of lime, muriate of lime, and carbonate of iron. The iron was in very small proportion; the carbonic acid and lime greatest. Now a dyer, learning his trade in a work where such a spring was used, could not fail to become a successful dyer *of all saddened colors;* but were he taken from this work to another where soft, filtered water was used, what would be the result? When he attempted to dye a black with the same quantity of dye-stuff he formerly used, he would only produce a dark slate color; and if he wished to obtain a slate color, he would produce a gray.† In this

* A technical name for colors that are darkened by sulphate of iron, which includes drabs, fawns, grays, slates, some kinds of browns, blacks, &c.

† Mr. William Partridge, an English dyer and dye-stuff dealer, of 34 Cliff street, New York, in a Treatise on dyeing, published by him in 1834, very gravely remarks as follows:—"I had no conception when I left England that water could have had so great an effect in the production of color as I have since found it to

dilemma, the dyer adds stuff till he comes to the desired shade; but fancy dyes, bolstered up with stuffs, are not so pretty; besides, the employer, in consequence of this extra stuff must either submit to a loss, or discharge the dyer, who, no doubt considering himself ill-used, talks loudly of his ability in dyeing such colors, *and offers to prove that*

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possess. I have practised the art in this country in four states, and have found that given proportions of the same description of ingredients, would not produce the same color in any two; there would in each be a considerable variation in the hue and body of the color. I shall endeavor to draw such deductions from the facts that have been developed during my practice in both countries, as will carry conviction to every unprejudiced mind; and I hope *my opinion will be entitled to that consideration which the importance of the subject demands.* For confirmation of the fact, that waters differ so materially as to cause a change in the hue and body of colors, I will mention two circumstances that have come under my notice, one of recent occurrence, the other of many years standing. The latter occurred to Mr. John Parish, *an eminent dyer* in the west of England. He commenced dyeing in Gloucestershire, and could not succeed; he then began in Wiltshire, and for thirty years was the *most eminent dyer in the country.* After which he commenced again in Gloucestershire, and in a few years lost all he made in Wiltshire, from an inability to make good colors." Again, "a dyer from Gloucestershire," says our author, "*being determined to ascertain the difference in dyeing black in Wiltshire, had a blacking of broadcloth prepared in Gloucestershire, and the ingredients he used there weighed out. He took with him the cloth and ingredients, and made a dyeing at Trowbridge, Wiltshire, with the same ingredients he had always made good bright colors in Gloucestershire, but the color produced in Wiltshire was a dead, flat, brownish, poor black.*"

After a few observations of a similar nature, Mr. Partridge further observes, "I have made two or three attempts to substitute caustic and sub-carbonated lime water, in place of the natural; having previously inferred that a similar effect would be produced. I found it to raise the color of the logwood, yet for want of sufficient experience in its use to fix a proper standard, I have never been able, successfully, to imitate the natural water. I have discovered, however, that when too much was used, it had an injurious effect, making the logwood tincture of a pale Prussian blue color." "The most important deduction," says he, "to be drawn from these *facts* is, *that dyers ought never to expect that recipes obtained from other countries, or from distant parts of their own, should produce exactly the same colors when used by them, as they have with others.* And also, that for dyers to become eminent, *they must be stationary*, they must continue to practice *in one situation*, and with *one kind of water*, that by these means alone, can they be expected to obtain perfection in the art. It is, nevertheless, useful to become acquainted with the practice of others, and more particularly with the science of chemistry, on which the art is founded; *but they must not implicitly rely on anything but their own practice.*"—Partridge on Dyeing, p. 28.

the fault is not in him but in the water. Were this wholly a supposed case, we would pause here and make an apology to our brethren for these remarks; but not being so, we will rather endeavor to show that the fault is the dyer's. Dyeing being an art *wholly* dependent upon chemistry for its development and *successful* practice, he who practices it without studying chemistry, *is like a boy learning to repeat a number of choice sentences from an author, without knowing his letters.* Had the dyer alluded to known the principles of chemistry, so far as they are applicable to his trade, he would, on finding that the same quantity of stuffs did not yield the same results, have examined the water to discover where lay the difference, and in this particular case he would find, that instead of adding sumac, copperas, and logwood extra, to get a good black, *a little chalk, and hydrous gypsum, added to the water,* would so qualify it as to render it equally effective with that to which he had been accustomed.

Having now pointed out some of the qualifications necessary for a good dyer, it is to be regretted that these qualifications have been much neglected. Chemistry has got far ahead, and in many instances can scarcely be identified in his processes—*while obsolete theories cling most tenaciously to him.* Scientific chemistry is also much retarded by his neglect. Who is better qualified to advance a science which depends wholly upon experiment, than the man whose daily avocations are a continued round of experiments?—And yet the dyer, for the want of a little observation, and not taking advantage of the inductions of scientific men, is comparatively ignorant of chemistry; and the theoretical man, for want of the dyer's experience, comes to hasty and erroneous conclusions, or overlooks the niceties requisite for a successful dyeing experiment. In proof of this, we shall cite two instances:—"Concentrated nitric acid acts very strongly upon iron filings, much nitrous gas is disengaged at the same time. The solution is of a reddish-brown color, and deposits the oxide of iron. After a certain time, more especially if the vessel be left exposed to the air, a diluted nitric acid affords a

more permanent solution of iron, of a greenish color, or sometimes of a yellow color. *Neither of the solutions affords crystals.*"* Now, long before this paragraph was written, the dyers, who use this salt in great quantities, were often annoyed by its crystalizing. The other is from a little work well adapted for a beginner.† "Add to a solution of sulphate of indigo an equal quantity of carbonate of potash; a piece of yellow cloth dipped in this will be changed to green, and a piece of blue litmus paper to red." Now, every dyer who knows anything of this process, is aware that if the sulphate of indigo would turn blue litmus red, it would not dye a yellow piece green; for the acid which turned the litmus red would *strip off*, as dyers term it, the yellow: hence, instead of a green, would result a dirty blue, which could not be dried without injuring the cloth, and if previously washed, the color would disappear. Now, a dyer, meeting such statements, generally comes to a wrong conclusion: reasoning from analogy, he sets aside the valuable researches of these authors, *because they have been unable to describe the practical details of dyeing a particular color, which none but a practical dyer is able to do.* But such evils will continue, so long as the practical and the theoretical man remain two persons. —(See chapter II., Part I., and chapter II., Part V., article *Olive.*)

CONSTRUCTION OF DYE-HOUSE.—It may be regarded, says Berthollet, as a general principle, that processes performed in a great manufactory, are more advantageous than those which are insulated, since from the subdivision of labor, each workman, occupied with a single object, acquires celerity and perfection in his employment, and since every thing being concatenated, each portion of the work is carried forward without loss of time; this principle should be applied to dyeing for a peculiar reason, because the residuum of one process can frequently serve for another. A bath which is found to be too much exhausted for one color, or even for what is called the *suites*, or gradations of color, may either

* Ure's Dictionary of Chemistry. † Griffin's Chemical Recreations.

give a ground to other dye-stuffs, or form a new bath, by mixing other ingredients with it.

It is essential to a dye-house, that it be placed where there is an abundance of good water to supply it, and plenty of fall to carry off the spent dye-stuff. The floor of the dye-house, says Mr. Cooper, should be of *hard* brick closely set, with drains and channels to carry off waste liquor. If not of brick, it should be of stone, or of hard cement, or leached ashes; so as to admit of being accurately washed. The light should be good and in plenty, without letting in too much sunshine: it should come from above; that is, the bottoms of the windows should be twelve or eighteen inches above the rim of the coppers: the shade of color is thus most advantageously discerned. There should be conveniences for carrying off steam. The coppers, except one for logwood which may be of iron, should be of brass or copper, and no iron nails be used about them. They should have covers to be used occasionally. The scarlet dye-house should be separate, and the vessels in it should be of tin, or tinned copper.* It would be better also, says Berthollet, if the black and blue dyes were at a distance from the other colors: want of extreme cleanliness, is a want that occasions great waste and expense, which ultimately falls on the dyer. Poles should be fixed in the walls over the copper for the skeins and hanks to hang on, that the dye-liquor dripping from them, may fall back into the copper.

Ladles, wooden shovels, barrels, ladders and barrows, nets and crosses, for wool, winces or reels for piece work, shovels for lime, &c., should be provided of course. The ladders, barrows, and winces, should be kept as much as possible to the use of one kind of color, and scrupulously clean. Where there is room and convenience, the implements of the establishment should occupy their own quarter: the scarlet dye-house, the blue dye-house, and the black dye-house, should not be intermingled with the apparatus used for other colors. Scar-

* As tin is absolutely necessary in the scarlet dye, it is much better to have the cauldron made of this metal, which infallibly contributes to the beauty of the color.

let, and blue, should be alone. The black may be contiguous to the drabs, olives, bottle greens, or to the chocolates, but should not be next to the pinks or yellows.* It is also desirable for the advancement of the art, as well as that of science, that a small place should be reserved, in which the apparatus necessary for the common experiments of chemistry and the trial of dyes may be collected.

* A well-planned dye-house should be an oblong gallery, well lighted, with a stream of water flowing along in an open conduit in the middle line, a series of dash-wheels arranged against the wall, at one side, and of dyeing coppers, furnished with self-acting reels against the other. In such a gallery, the washing may be done either by hand, by the rinsing machine, or by the dash-wheel, according to the quality of the dye, and the texture of the stuffs, (see Dyeing and Calico Printing). And they may be stripped of the water either by the jack and pin, by the squeezing roller, or by the press. Wooden pins are placed in some dye-houses on each side of the wash cistern or pool. They are somewhat conical, 1½ feet high, 3½ inches in diameter at the base, 1½ at the top, are fixed firmly upright, and at a level of about three feet above the bottom of the cistern, so as to be handy for the workmen.—*Ure.*

CHAPTER III.

OF RED.

PROCESSES OF DYEING RED ON COTTON.

Preliminary observations—Madder Red—Adrianople, or Turkey-Red—French, German, and Scotch Processes, with the Recent Improvements—Imitation Turkey-Red—Barwood, Improved method of Dyeing with—Brazil-wood, Superior Processes of Dyeing with—Safflower Pink.

Preliminary observations.—Intense red is the most powerful of colors in regard to its effect upon the eye, and in the coloring of nature it occurs rarely and in small portions. Its effect in art when covering any large space, is gorgeous and powerful; and on all occasions the predominance of red is ostentatious, and congenial to the most primitive ideas of grandeur.

The hues with which it melodises in series are, of course, orange and purple, being its combinations with the other two primaries (blue and yellow). Its contrasting color is green, a compound of yellow and blue, in the proportion of three yellow to eight blue. Red is decidedly a warm color, and to a certain extent, communicates this quality to every hue into which it enters. This effect of warmth is most apparent in its combinations with yellow: for in those with blue it becomes more cool and retiring. From the medial situation of red, and from its power in subduing the effect of such colors as enter, in minute proportion, into combination with it, its name is very indiscriminately applied. The first decided hue produced, in its approach towards yellow, is scarlet; and, in its approach towards purple, it produces the most splendid of all hues of this description, crimson. But before arriving at either of these understood colors, there are an immense variety of hues, to all of which the general term red is com

monly applied. It is not easy to describe what is meant by pure red; probably the most intense *geranium* color is the nearest approximation.

The tertiary in which red predominates is russet, a medial hue between purple and orange, and consequently having a double occurrence of red in its composition; therefore, it is the most positive and warm of the neutral colors. It is of great power and value in all the deep parts of any warm-toned arrangement, as a contrasting color to the deep hues of green, necessarily brought in as relieving colors. The semi-neutral marone is the next understood hue in its descent to black. This hue is the most useful of all semi-neutrals in such arrangements as are best adapted for patterns of *carpets*, and other *variously-colored* manufactures. It is deep and clear, and although allied to red, is sufficiently cool to admit of its being used as the deepest shade in such arrangements as have a predominance of cool-toned colors.

From the positive nature of red, there is no color that requires more toning and management. The effect of red individually being striking and powerful, it has, like yellow, been too indiscriminately employed. We have only to look at nature for the proper use of this color. We shall there see that red seldom appears in its full intensity, and when it does so, it is at that season when its effect is balanced and neutralized by the general verdure which clothes the earth. Red, however, in nature as in art, is indispensable in producing, by combination, that variety of hue so essential to the effect of every arrangement of colors. The landscape painter knows well that neither sky, water, nor foliage, can be successfully imitated without the introduction of this color.

Pure red, and its various hues of scarlet, are too violent and obtrusive to be used in large masses, either in decoration or in any general arrangements of colors upon a piece of manufacture, unless under very peculiar circumstances. It forms, however, like orange, an excellent leading color or key-note. On all such occasions its contrasting color, green, ought to be neutralized by being brought in tone towards olive: bright green, if employed at all, should be used in

very small quantities. The tertiaries should generally be those in which red predominates, and blue subordinate to yellow, and these relieved by deep rich tones of green.

Crimson is, of all the hues arising from the mellowing of the primary red, the most gorgeous and useful as a leading color. The green which relieves it best is that which approaches the citron hue. This color, from the splendid and rich effect which it produces, and from its being, of all the hues of red, the most cool and mellow, is much used in internal decoration. It is also, when of a proper shade and tone, an excellent ground for pictures, and associates well with gilding. This latter quality proceeds from the crimson partaking, in a small degree, of the property of purple as well as red—the one being the contrasting color to yellow, and the other the melodising color to orange; the color of gold in its lights and shadows producing these two.

From crimson proceeds that beautiful series of tints* called pinks or rose colors, which are so essential and effective as heightening reds in all cool-toned arrangements.

There are various other denominations of red. Syme has *eighteen* altogether; but they are all, with the exception of the purest color, compounds of two or all of the primaries.

Amongst flowers, red is a predominating color, often in great purity, as in the flower of the verbena, the geranium, and many others. Its various gradations of tint are nowhere more beautifully and delicately displayed than in the ordinary varieties of the rose; and it is often beautifully blended with its contrasting color green, in the productions of the orchard.

Red sometimes occurs in considerable purity in the natural productions of the mineral kingdom, both in transparent

* By tint is meant every gradation of a color in lightness, from its most perfect or intense state up to white. This applies also to every one of the hues, for they are, as well as the colors, capable of every state of dilution. The variety of tint is therefore incalculably greater than that of hue. By shade is meant every gradation of a color or hue in depth, from its perfect state down to black.

and opaque substances. Of the former, the oriental ruby is the most conspicuous, and of the latter, the mineral called cinnabar, a native sulphuret of mercury, (see Appendix, articles *Cinnabar* and *Vermilion*,) but, perhaps, the nearest approximation to pure red in nature, is the production of the animal kingdom, the cochineal. Many of the feathered tribes, also, exhibit it in much perfection and beauty in the plumage with which nature has adorned them. But it would be an endless task, and apart from the object of this work, to go into minute details regarding the infinite varieties of color which the botanist, the naturalist, and the mineralogist, find amongst the objects of their study. Our purpose is, however, *to attempt to classify, arrange, and define colors, in order to enable those who are following such branches of study, as well as the artist, more easily to comprehend the nature of each particular hue, tint, and shade, and the relation that it bears to the primary elements of light, darkness, and color.* By this knowledge, a description may be given where no proper name can be applied, and every compound become as well understood as the primary elements, *yellow*, *red*, and *blue*.

In art, the purest red that can be produced is carmine, a pigment made from cochineal, (see *Vegetable Coloring Substances*, chapter III., Part I.) In sunshine and in artificial light, red is more brilliant than in daylight, and is most deteriorated when viewed in a northern aspect, when the sky is clear.

PROCESSES OF DYEING RED.*—Although the dye-

* *Scarlet.*—This color is very seldom dyed on cotton. Dr. Berkenhout's flimsy process, containing nothing new, may be found in Bancroft's treatise on the art of dyeing, vol. i., p. 398. If this color be wanted, says Mr. Cooper, it may be dyed in the following manner:—1. Boil the bleached cotton in a preparation of two ounces of alum per pound of cotton, for an hour and a half. 2. Take it out, drain it, and without rinsing run it through water for an hour, at 110° F., in which fresh blood has been mixed, in the proportion of half a pint of blood to a pound of cotton. Then drain and rinse it. 3. Dye with an ounce of quercitron, to the pound of goods; wash well and dry. 4. Now rinse the goods for an hour and a half through a boiling preparation, consisting of sufficient quantity of water, mixed with the common composition for the scarlet dye: drain it, rinse it slightly. Then

ing of *cottons* is mostly practised as a part of the process of calico-printing, nevertheless, the *chemical principles* involved in the different operations *are precisely the same*, whether the cloth is merely dyed and finished in that state, or both printed and dyed. The principal substances used for producing red on *cotton*, are Madder, Barwood, and Brazil-wood.*

MADDER RED.—Madder, in the hands of a skilful dyer, can be made to produce almost any color (of which red is the principal,) by varying the mordants, and the colors produced are all characterised by a degree of permanency which no other dyewood possesses; but the operations for obtaining them are generally tedious. Much skill is also requisite for obtaining and applying the proper mordants for madder.

The first step in dyeing full and permanent colors by madder, is clearing the cotton well with alkaline leys, and then in oily liquor, in which sheep's dung is macerated; this operation is repeated several times, according to the nature of the colors wanted. Many attempts have been made to substitute different salts for the sheep's dung, and in some cases with considerable success; but the accounts given of these experiments we have always considered a little exaggerated. There appears to be some peculiar influence in the dung to fulfil the purpose intended, that no substitute we have seen tried can equal. After the goods are considered sufficiently prepared by the alternate washings and macerations, they are, what is termed in the language of the dye-house, *gall*—that is steeped, or wrought for some time in a decoction of galls, or what is now more commonly used, sumac, when they are ready to receive the proper mordant for the

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dye it in the common finishing or cochineal or scarlet bath, and wash it well. If too red, it may be run through a very dilute preparation liquor. If too yellow, run it through hot water, with about an ounce of the whitest soap dissolved in it, to twenty pounds of cloth: or the quantity of cochineal may be increased. A second blood liquor after the tin preparation, would, no doubt, be of use. The blood certainly makes the color more permanent, but scarlet by cochineal, is fugitive upon cotton at the best.

* The other substances for producing red on cotton, will be detailed in their proper place as we proceed with the subject.

color required. The various mordants used, are the following:—

1. Acetate of alumina. 2. Acetate of iron, or sometimes a mixture of these two for different shades of brown. 3. Chloride of tin. 4. Acetate of lead,* and, for variety of shades, the ammoniate and acetate of copper.

In dyeing with madder by an iron mordant, it is of the utmost importance that the iron be applied in the state of a protosalt. We have already alluded to† an easy method of applying the iron salt in this state by adding a piece of clean iron to the liquor some time previous to using, by which means any persalt is reduced to the state of a protosalt; but it requires great caution and dexterity to preserve it in such a state when applied to the cloth for such a length of time, as from the mordanting to the immersion in the dye-bath.‡

We may here also observe that the proper proportion of water to madder, in the bath, is from ten to twelve quarts to the pound of madder; a very concentrated decoction does not give out the color freely.

ADRIANOPLE OR TURKEY-RED.—This is the most complicated and tedious operation in the art of dyeing; but it produces the fastest color which is known. This dye was discovered in India, and remained long a process peculiar to that country. It was afterwards practised in other parts of Asia and Greece. In 1747, Ferquet and Goudard brought Greek dyers into France, and established near Rouen, and in Languedoc, Turkey-red dye-works. In 1765, the French government, convinced of the importance of the business, caused the processes to be published. In 1808, Reber, at Mariakirch, furnished the finest yarns of this dye, and M. Kœchlin became celebrated for his Turkey-red cloth. This gentleman has immortalised his name in the annals of calico-printing, by a discovery which he made in 1811. It consists in *printing* upon Turkey-red, or any dyed color, some pow-

* See *Appendix*, article *Acetate of Lead*.

† See *Iron*, chapter I. of this Part; see also chapter II. of this Part, article *Tannin and Gallic Acid*.

‡ See chapter III. Part I., article *Madder*, and chapter I. Part VI.

erful acid, and then immersing the cloth in a solution of chloride of lime. Neither of these agents singly affects the color, but those parts which have received the acid, on being plunged in chloride of lime, are speedily deprived of their dye, and made white by the acid of the liberated chlorine. This is one of the beautiful facts in the chemistry of calico-printing.

For this process a patent was obtained in England, by Mr. James Thomson, of Primrose, near Clitheroe, in the year 1813; and the same gentleman, in 1816, took out a second patent for a very useful and happy modification of the principle of the former one, namely, for combining with the acid some mordant, or metallic oxide, capable, after the colors were removed, of having imparted to it some other color. This laid the foundation of that series of processes, in which the chromic acid and its combinations have since been employed with such great success.

The first person who established, in Great Britain, a factory for dyeing Adrianople or Turkey-red, was M. Papillon, who, in the year 1790, obtained a premium from the Commissioners and Trustees for Manufactures in Scotland, for communicating the details of it to Dr. Black, on condition that it should not be divulged for a certain term of years. The term being expired, the process was published. It resembles pretty closely the method described by M. Berthollet in his "Elements of Dyeing."* Those who wish to compare them, will find M. Papillon's in the 18th volume of Tilloch's Magazine, p. 43.

THE GERMAN PROCESS IMPROVED, according to Dingler, consists of the following operations: mordant of an oily soap or a soapy liniment, hard drying; galling, alkaline bath, drying, steeping, rinsing, drying; galling, drying, aluming, drying, steeping in water containing chalk, rinsing; maddering, airing, rinsing; brightening with an alkaline boil, and afterwards in a bath containing salt of tin; then

* Vol. II. p. 122.

washing and drying.* The yarn must be first well worked in a bath of sheep's dung and oil, compounded as follows:—

25 pounds of sheep's dung are to be bruised in a solution of pure caustic potash of hydrometer strength 3°, and the mixed liquor is to be passed through a sieve. Two pounds of fine oil should now be poured into 16 pounds of this ley, after which 30 pounds of coarse oil are to be added, with agitation for ¼ of an hour. An additional 4 pounds of hot ley are to be well stirred in, till the whole is homogeneous. This proportion of mordant is sufficient for 100 pounds of cotton yarn, for 90 pounds of unbleached or 100 pounds of bleached cotton goods. The goods, after being well wrung out, are to be laid in a chest and covered with a lid loaded with weights, in which state they should remain for five days. At the end of 24 hours, the cotton becomes hot with fermentation, gets imbued with the mordant, and the oil becomes rapidly altered. The goods are next exposed freely to the air during the day, and in the evening they are dried in a hot chamber, exposed to a temperature of 158° F., for 6 or 8 hours, which promotes the oxidizement of the oil.

The goods are now passed the second time through a soapy oil mordant similar to the first, then dried in the air by day, and in the hot stove by night. The third and fourth oil-soap steeps are given in the same way, but without the dung. The fifth steep is composed of a ley at 2°, after which the goods must also be dried. Indeed, from the first to the fourth steep, the cotton should be put each time into a chamber heated to 145° F. for twelve or fifteen hours, and during eighteen hours after the fifth steep. The uncombined oil must, in the next place, be removed, which is effected by steeping the goods for six hours in a very weak alkaline ley. After rinsing and wringing, they are dried in the air, and then put into the hot stove.

The goods must now be galled in a bath formed of thirty-six pounds of Sicilian sumac, boiled for three hours in 260 pounds of water, filtered, the residuum is treated with 190 fresh pounds of water. This decoction is heated with 12 pounds of pounded galls, to the boiling point, allowed to cool during the night, and used next morning as hot as the hand can bear; the goods being well worked through it.

* Linen takes the color of madder with more difficulty than cotton; but the processes which succeed best with the one, are also preferable for the other. The difference, however, is not very great when the yarn is slightly twisted.

They are again dried in the air, and afterwards placed in a stove and moderately heated. They are next passed through a tepid alum bath, containing a little chalk; left afterwards in a heap during the night, dried in the air, and next in the stove. The dry goods are finally passed through hot water containing a little chalk, wrung out, rinsed, and then maddered. For dyeing the following is the order to be observed:—

The copper being filled with water, the fire is kindled, and an ounce and a half of chalk is added for every pound of madder; a pound and a quarter of madder being taken for every pound of cotton yarn. The goods are now passed through the bath, so that they penetrate to near its bottom. The fire must be so regulated, that the copper will begin to boil in the course of from 2½ to 3 hours; and the ebullition must be continued for an hour; after which the yarn is aired and rinsed. Cloth should be put into the dye-bath when its temperature is 77° and winced at a heat of from 100° to 122° during the first hour; at 167° during the second; and at the boiling point when the third hour begins. It is to be kept boiling for half an hour; so that the maddering lasts four hours.

After being dyed, the goods are washed, pressed, and subjected to a soapy alkaline bath at a high heat, in a close boiler, by which the dun parts of the galls and the madder are dissolved away, and the red color remains in all its lustre. This operation is called *brightening*. It is repeated in a similar liquor, to which some muriate of tin is added for the purpose of enlivening the color and giving it a rosy tint.* Last of all the goods are rinsed and dried in the shade.

Cottons which have not been suitably worked in the preparations, come out of the maddering with a thin color, sometimes of a brick hue. Before brightening these cottons, they should get new oil baths, and the operation repeated as if they had not been dyed. The brightening and *rosing* will have a little less power than in ordinary cases.

THE ELBERFELD PROCESS.—The manipulations for 100 lbs. of yarn, according to this process, are as follows:—

1. Cleansing the cotton by boiling it for four hours in a weak alkaline bath,† cooling and rinsing.

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* See chapters I., V., and VI., Part VI.

† The alkaline ley occasions a greater separation in the particles of the oil, by which it combines more closely with the fabric of the cloth.—*Ure.*

2. Working it thoroughly, four times in a steep, consisting of 300 pounds of water, fifteen pounds of potash, 1 pailful of sheep's dung,* and 12¼ pounds of olive oil, in which it should remain during the night. Next day it is drained for an hour, wrung out and dried. This treatment with the dung steep, and drying, is repeated three times.

3. It is now worked in a bath containing 120 quarts of water, 18 pounds of potash, and 6 quarts of olive oil; then wrung out and dried. This steep is also repeated 4 times.

4. Steeping for a night in the river is the next process; a slight rinsing without wringing, and drying in the air.

5. Bath made of a warm decoction (100° F.) of sumac and galls, in which the goods remain during the night; they are then strongly wrung, and dried in the air.

6. Aluming with addition of potash and chalk; wringing; working it well through this bath, where it is left during the night.

7. Draining, and strong rinsing the following day; piling up in a water cistern.

8. Rinsing repeated next day, and steeping in water to remove any excess of alum; the goods continue in the water till they are taken to the dyeing-bath.

9. The maddering is made with the addition of blood, sumac, and galls; the bark is brought to the boil in 1 hour and ¾, and kept boiling for half an hour.

10. The yarn is rinsed, dried, boiled from 24 to 36 hours in a covered copper, with an oily alkaline liquid; then rinsed twice, laid for two days in clear water, and dried.

11. Finally, the greatest brightness is obtained by boiling for three or four hours in a soap bath, containing muriate of tin; after which the yarn is rinsed twice, steeped in water, and dried.

According to Berthollet, a great variety of shades may be

* The sheep's dung in the first immersions may serve as a covering or great coat, to keep the goods moist for a considerable time, that they may more fully imbibe the liquor, by preventing the evaporation from being too quick in the great heat to which they are exposed.—*Elements of the Art of Dyeing*, Vol. II. p. 392.

procured, by giving another color to the goods before passing them through the oil bath.

Pallas relates in the Journal of Petersburg for 1776, that the Armenians, whom the troubles of Persia obliged to retire to Astracan, dye Turkey red by impregnating cotton with fish oil, and drying it alternately during seven days; that they have remarked that the other oils would not succeed; that they did not take indifferently the oil of every fish, but chose that of certain fish, which becomes milky whenever an alkaline solution is mixed with it. After these repeated impregnations and desiccations, they wash the cotton, and dry it. They give it then an astringent bath, into which they put a little alum. They dye it in a bath of madder, with the addition of calf's blood. Lastly, they digest it for 24 hours in a solution of soda.

"If cotton dyed with madder, by any process whatsoever, be boiled for some minutes in soap water, it assumes a rose color. If it be then squeezed, a fat matter is expressed from it, which has the color of Adrianople red, and which fixes itself on white cotton. Œtinger observed, in 1764,* that oil had the property of dissolving the coloring part of the Adrianople red, so that, if it be moistened with oil, its color is communicable to white cotton when rubbed with it for some time. He thence concluded, that oil must enter into the preparation of the Adrianople red; and the Abbé Mazeas proved long ago, that oil was indispensable to this dye.†

"The species of madder employed has a great influence on the color. It appears indispensable, for procuring a color equal to the Adrianople red, to employ the kind called *lizari*, (fine madder.)‡

"We should distinguish, in madder-dyed cotton, between the faculty of resisting, for a long time, the action of the air, and that of resisting alkalies and soap. The last can be ob-

* Dissertatio de viribus radicis rubiæ tinctorum antiarchiticis a virtute ossa animalium vivorum tingendi non pendendibus.

† Recherches sur la cause physique de l'Adherence de la Couleur Rouge, &c.—*Mem. des Savans Etrangers*, tom. iv.

‡ See chapter III. Part I., article *Madder*, and chapter I. Part VI.

tained only by means of oils and fats; but the first depends chiefly on the mordants that are used, and the other manipulations."*

Dr. Bancroft, in speaking of the mode of dyeing this red in the East, says, that the cotton is soaked in oil (no matter of what description†), during the night, and exposed to the sun for seven successive days, rinsing it only in running water, and then immersing it in a decoction of galls and leaves of sumac previous to aluming.

Upon the ascertaining of this, Dr. Ure advises *practical dyers* "to give up the idea of animalization, if by it be meant impregnating the cloth with an animal matter, and by the power of the microscope, or any better method, look for the whole truth from some other source than chemical analysis." "A very eminent calico manufacturer," says he, "whom I consulted on the Turkey red process, assured me, that the only essential mordants are oil and alumina; and that bright and fast reds, equal to any produced by the usual complicated process with sheep's dung, galls, and blood, may be obtained without these articles."‡

These statements of Dr. Ure, are, *in practice*, found to be erroneous, notwithstanding "the power of the microscope," and the authority of "the very eminent calico manufacturer" above alluded to.

We highly approve of the two distinct processes of animalization in this dye: first with the sheep's dung, secondly with the blood. We know the effect is not only good but indispensable to the perfection of the color, and we strongly incline to recommend this practice to be extended to all madder reds and colors of which madder red is the basis.

It will be seen also, that Messrs. Monteith and Co., who may, with justice, lay claim to a thorough knowledge of this subject, use both the blood and the dung in their process of

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* *Elements of the Art of Dyeing*, Vol II. p. 144.

† Olive oil, hog's lard melted, oil of sessamum, &c., have all been used with success.—*Bancroft.*

‡ *Elements of the Art of Dyeing*, vol. II. p. 393. (*Ure's Notes.*)

obtaining this color, and we presume their experience is, at least, as extensive, for any practical purpose, as that of Dr. Ure.

M. HAUSSMAN'S PROCESS.—He treats cotton twice or four times in a solution of aluminated potash, mixed with a thirty-eighth part of linseed oil. The solution is made by adding caustic potash to alum. He dries and rinses each time, and dries after the last operation. He then rinses and proceeds to the madder bath. For the rose color, he takes a pound of madder to the pound of cotton; for carmine reds, from two to three pounds; and for the deepest red, no less than four pounds.* It is said that the color thus obtained surpasses Turkey red.

THE FRENCH PROCESS, BY M. VITALIS.†—1. Scouring with a soda ley, of 1° Baume, to which there is usually added the remainder of the *white*,‡ preparation bath, which consists of oil and soda with water. It is then washed, wrung out, and dried.

In the second operation, he states that from 25 to 30 pounds of sheep's dung are commonly used for 100 pounds of cotton yarn. The dung is first steeped for some days in a ley of soda, of 8° to 10° B. This is afterward diluted with about 500 pints of a weaker ley, and at the same time bruised with the hand in a copper basin, its bottom being pierced with

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* A quantity of which we are well persuaded nearly half, at least, is wasted. We do not believe that cotton can be made to take up, per pound, the coloring matter of more than two pounds of the best madder. Certainly not over two and a quarter. Economy of stuffs is the primary object of all good dyers, not only on account of the expense, but from the fact also, that the more exact the proportion of the materials to the hue wanted, the finer and brighter is the color obtained, and the less is the time expended upon it.

† Berthollet, vol. ii., p. 397.

‡ From the following observations, it appears that Dr. Ure has abandoned the notion that *animalization is not necessary* in the Turkey red process:—The *white* bath is prepared by pouring six pounds of fat oil into fifty pints of soda water, at 1° or sometimes less, according as, by a preliminary trial, the oil requires. This bath should be repeated two, three, or even a greater number of times, as more or less body is to be given to the color. To what remains of the white bath, and which is also styled *avances*, about 100 pints of soda ley of two or three degrees are added. Through this the cotton is passed as usual.—*Ure.*

small holes. The liquor is then poured into a vat containing five or six pounds of fat oil (Gallipoli), and the whole are well mixed. The cotton is washed in this, and the hanks of yarn are then stretched on poles in the open air, and turned from time to time, so as to make it dry equally. After receiving thus a certain degree of desiccation, it is carried into the drying-house, which is heated to 50° Reaumur (144° Fahrenheit), where it loses the remainder of its moisture, which would have prevented it from combining with the other mordants, which it is afterward to receive. What is left of the bath is called *avances*, and is added to the following bath. Two, or even three dung baths are given, when it is wished to have very rich colors. When the dung baths have been given,* it should not be left lying in heaps for any length of time, lest it take fire; an accident which has occasionally happened.

The cotton is steeped for five or six hours in a tepid solution of soda, of 1° at most, drained, sprinkled with water, and at the end of an hour, washed, hank by hank, to purge it entirely from the oil. What remains of the water of degraissage (half bleaching) serves for the scouring or first operation.

For 100 pounds of cotton, from 20 to 25 pounds of galls must be taken, which are bruised and boiled in 100 pints of water, till they crumble easily between the fingers. The galling may be done at two operations, dividing the galls between them, which is thought to give a richer and more uniform color.

The aluming of 100 pounds of cotton requires from 25 to 30 pounds of pure alum, that is, alum entirely free from ferruginous salts. The alum should be dissolved without boiling, in about 100 pints of river or rain water. When the alum is dissolved, there is to be poured in a solution of soda, made with the sixteenth part of the weight of the

* The *white* baths, which follow those of dung, co-operate with the latter, giving to the cotton the oily principle, for which cotton is known to have a great affinity, and which, moreover, possesses the property of combining with the coloring matter. —*Ure.*

alum. A second portion of the alkaline solution must not be poured in till the effervescence caused by the first portion has entirely ceased—and so in succession. The bath of saturated alum being merely tepid, the cotton is passed through it, as in the gall bath, so as to impregnate it well, and is dried with the precautions recommended above. The dyers who gall twice, alum also twice, for like reasons.*

For 25 pounds of cotton, 25 pints of blood are prescribed, and 400 pints of water. Whenever the bath begins to warm, 50 pounds of madder are diffused through it; though sometimes the maddering is given at two operations, by dividing it into two equal parts.

The brightening bath is prepared, for 100 pounds of cotton, with from four to five pounds of rich oil, six pounds of Marseilles white soap, and 600 litres of soda water of 2° B. The rosing is given with solution of tin, mixed with soap water.

A good Adrianople red supports for ten minutes the action of nitric acid at 18° of the areometer, without suffering any sensible change. By letting it remain longer in the acid, or by employing a stronger one, the cotton becomes more and more orange, and finally loses its color. The simple madder reds, exposed to the same test, disappear in less than three minutes.

PROCESS OF MESSRS. MONTEITH & Co.—The calico is taken as it comes from the loom, without bleaching; it is then subjected to a fermentative steep for twenty-four hours, like that preliminary to bleaching, after which it is washed at the dash-wheel. It is next boiled in a ley, containing about one pound of soda crystals for twelve pounds of cloth. The oiling process now commences, and is as follows:—

A bath is made with ten gallons of Gallipoli oil, 15 gallon measures of sheep's dung not indurated; 40 gallons of solution of soda crystals, of 1·06 specific gravity; 10 gallons of solution of pearl-ash of spec. grav. 1·04; and 140 gallons of water; constituting a milk-white, soapy solution of about spec. grav. 1·022.

* The *avances* (residuary liquors) in which the cotton has been worked after the galling, are good for nothing, and must be thrown away.

This liquor is put into a large cylindrical vat, and constantly agitated by the rotation of wooden vanes, which are best constructed on the plan of the mashing apparatus of a brewery, but far slighter. This saponaceous compound is let off as wanted by a stopcock into the trough of a padding machine, in order to imbue every fibre of the cloth in its passage. This impregnation is still more fully ensured by laying the padded cloth aside in wooden troughs during sixteen or eighteen days.

The cloth is padded again with the saponaceous liquor; and again spread on the grass, or well dried in the stove. This alternation is repeated a third time, and occasionally, even a fourth.

The cloth by this time is varnished as it were with oil, and must be cleansed in a certain degree by being passed through a weak solution of pearl-ash, at the temperature of about 122° F. It is then squeezed by the rollers and dried. A second system of oiling now commences, with the following liquor:—

10 gallons of Gallipoli oil; 30 gallons of soda crystals ley, of spec. grav. 1·06, and 10 gallons of caustic potash ley, of spec. grav. 1·04, thoroughly diffused through 170 gallons of water.

With this saponaceous liquor the cloth is padded as before, and then passed between squeezing-rollers, which return the superfluous liquor into the padding-trough. The cloth may be now laid on the grass if convenient; but at any rate it must be well dried in the stove.*

These saponifying, grassing, and drying processes, are repeated three times; whereby the cloth becomes once more very oleaginous, and must be cleansed again by steeping in a compound ley of soda crystals and pearl-ash of the spec. grav. 1·012, at the temperature of 122°. The cloth is taken out, squeezed between rollers to save the liquor, and washed. A considerable portion of the mingled alkalies disappear in this operation, as if they entered into combi-

* See chapters I., II., III. and IV., Part VI.

nation with the oil in the interior of the cotton filaments. The cloth should now be dried.

Galling is the next great step in the Turkey-red preparation; and for its success all the oil should be perfectly saponified. The proportions and mode of operating are as follows:—

From 18 to 20 pounds of Aleppo galls (to every 100 pounds of cloth) are to be bruised and boiled for three or four hours, in 25 gallons of water, till 5 gallons be evaporated; and the decoction is then passed through a scarce. Two pounds of sumac may be substituted for every pound of galls.

The goods are to be well padded with this decoction, kept at 90° F., passed through the squeezing-rollers, and dried. They are then run through a solution of alum of the spec. grav. 1·04, to which a certain portion of chalk is added to saturate the acid excess of that supersalt; and in this cretaceous mixture, heated to 110°, the cloth is winced and steeped for twelve hours. It is then passed between squeezing-rollers, and dried in the stove.

Maddering.—This process comes next.—From two to three pounds of madder ground to powder, are taken for every pound of cloth. This, as usual in maddering, is entered in the cold bath, and winced for one hour, that the bath takes to boil, and during an ebullition of two hours afterwards. One gallon of bullock's blood is added to the cold bath for every 25 pounds of cloth; being the quantity operated upon in one bath. The utility of the blood in improving the color has been ascribed to its coloring particles; but it is more probably owing to its albuminous matter combining with the margarates of soda and potash condensed in the fibres.

As madder contains a dingy brown coloring matter associated with the red, the goods must be subjected to a clearing process to remove the former tinge, which is more fugitive than the latter. For this clearing process the following are the ingredients used:—

Every hundred pounds of cloth are boiled during twelve hours, at least, with water containing five pounds of soda crystals, eight pounds of soap, and 16 gallons of the residual pearl-ash and soda ley of the last cleansing operation.

By this powerful means the dun matter is well nigh removed; but it is completely so by a second boil, at a heat of 250° F., in a tight globular copper, along with 5 pounds of soap, and 1 pound of muriate of tin crystals, dissolved in a sufficient body of water for 100 pounds of cloth. The muriate of tin serves to raise the madder red to a scarlet hue. A margarate of tin is probably fixed upon the cloth in this operation. When the weather permits, the goods should be laid out for a few days on the grass. Some manufacturers give them a final brightening with a weak bath of a chloride of lime; but it is apt to impoverish the color.

M. Clerc, who conducted with success a manufacture of this kind at Vaudreuil, says, that "the cotton (in the last or finishing process) should not be withdrawn from the copper till the end of ten or twelve hours, because it becomes richer in the brightening and takes more lustre. It must thereafter be well washed, hank by hank, and dried, when the operation is complete." This gentleman is also in the habit of giving his cottons (after the dyeing processes are finished and the yarn is well dried,) one dip. The liquor for this purpose, "consists in making a solution of tin in aqua fortis, with $\frac{1}{16}$th of sal ammoniac. I dilute this solution with eight pailfuls of water, and pass the cotton through it. It must be afterwards washed. This dip gives great brilliancy to the color."

According to Berthollet, the intensity of the red depends on the quantity of madder employed in the dye; "with a weight of madder equal to the hanks," says he, "the color becomes rose by brightening; with four times the weight of the hanks of madder, the finest red is produced." No wonder.

THE FRENCH PROCESS IMPROVED.—According to the latest improvements of the French dyers, each of the four processes of oiling, mordanting, dyeing, and brightening, differ, in some respects, from the above. Their first step is as follows:—

1. The cloth is boiled for four hours, in water containing one pound of soap for every four pieces. The saponaceous

bath of a creamy aspect is used at a temperature of 75° F.; and it is applied by the padding machine six times, with the grassing and drying alternations. In winter, when the goods cannot be exposed on the grass, no less than 12 alternations of the saponaceous or white bath are employed, and 8 in spring. They consider the action of the sunbeams to aid greatly in brightening; but at midsummer, if it be continued more than four hours, the scarlet color produced begins to be impaired. It is thought that the oiling operation impregnates the fibres with super-margarate of potash or soda, insoluble salts which attract and condense the alumina, and the red coloring particles of the madder, so firmly that they can resist the clearing boil.

2. *Mordanting*,* which consists, first, in padding the pieces through a decoction of galls mixed with a solution of an equal weight of alum; and after drying in the hot-flue, &c., again padding them in a solution of acetate of alumina, made by decomposing a solution of 16 lbs. of alum with 16 lbs. of acetate of lead, for 6 pieces of cloth, each 32 *aunes*† long.

3. *Maddering*,‡ which is given at two successive operations; with 4 pounds of Avignon madder per piece each time.

4. *Brightening*, which is performed by a 12 hours' boil in water with soda crystals, soap, and salt of tin; and the *rosing* by a 10 hours' boil with soap and salt of tin. Occasionally, the goods are passed through a weak solution of chloride of potash. When the red has too much of a crimson cast, the pieces are exposed for two days on the grass, which gives them a bright scarlet tint.

Some dyers are of opinion that the color, when the brightening process has been completed, is improved by preserving the cotton for one or two months shut up pretty tight in hempen bags. This seems to show that the mordants have

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* See chapter I. of this Part.

† *Aune.*—A French cloth measure, but of different lengths in different parts of the country. At Rouen, it is an English ell; at Calais, 1·52; at Lyons, 1·061; at Paris, 0·95.—See *Appendix*, article *Measure*.

‡ See chapter I. Part VI.

not completely exhausted their action in the operation itself, and that the affinities between them and the coloring matter require a certain time to produce their whole effect.

COMMON RED.—A good red may be obtained in the following manner:—

1. Soak the goods for twelve or fourteen hours in acetate of alumina. 2. Drain and wring; gall with three ounces to the pound of goods. 3. Dye with a pound and a half of madder and two ounces of Brazil-wood to the pound of goods. 4. Brighten with an ounce of soap, to the pound of goods, boiling for fifteen minutes, putting in the goods when the soap is dissolved.

Warp yarns being harder twisted than those for wefts, require more manipulation to give them an equally good color. Linen yarn, according to Berthollet, takes a color almost as brilliant as that of cotton, but it must be passed through double the number of oils and leys. The latter should be very strong, otherwise the oil flows out on the surface. The greatest attention must be paid to the scouring at first; for the yarn entangles by the heat, to such a degree that it can be neither dipped nor unravelled.*

BARWOOD RED.†—The following method, with a little attention, will give the finest shades of red:—

1. For every twenty pounds of goods, whether cloth or yarn, take four pounds of sumac well boiled in a sufficient quantity of water, to allow the goods to steep in it without being hard pressed, the clear decoction of sumac being drawn off as soon after being boiled as possible; to this are added two ounces, by measure, of

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* *Turkey, or Adrianople Red.*—Mr. Cooper gives us the following recipe, with emendations, for obtaining this color, and which, he says, he copied while in Manchester, previous to the publication of his book on dyeing:—1. Boil the gray cotton in water for an hour and a half, with an ounce of soft soap to the pound. Wash. 2. Dissolve in five quarts of water an ounce of pearlash, and as much fish oil, or Gallipoli oil, to the pound of cotton. Let the goods macerate in this liquor, hot, for six hours; wash. 3. Steep during ten days in fish oil. 4. Wring, rinse well, and dry. 5. Gall with four ounces and as much sumac, to the pound of goods: wring and rinse; run for an hour and a half through alum liquor, (steeping the goods for six or eight hours in the acetate of alumina, is much better,) four ounces to the pound. Again through the astringent liquor; then through the alum liquor, refreshed with an ounce of alum. 6. Run through sheep's dung; rinse immediately; wring. 7. Dye in a madder bath, with a pound and a half of madder, and half a pint of blood to the pound of goods. 8. Wash. Brighten with white soap and water.

† See chapter III., Part I., article, *Barwood.*

sulphuric acid; the goods are allowed to steep in this for ten or twelve hours. If six pounds of sumac be used for the twenty pounds weight of goods, four hours' steeping will do.

When the goods are taken from the foregoing liquor, they are wrought through *spirits*, prepared in the following manner, at the density of 3° Twaddell or 1·015 specific gravity :—

2. Take six measures muriatic acid and one of nitric acid, add tin by degrees until white bubbles begin to rise to the surface; allow this to stand for twelve hours before using.*

The goods are wrought in this till they assume a rich light lemon color, or say for fifteen minutes, then washed in cold water until there is no perceptible taste of acid; after which they are put into a tub of hot water and well rinsed. One pound of barwood is taken for every pound of goods, and put into a boiler large enough to allow the goods sufficient freedom to float through it.

3. The goods prepared as above are entered ten minutes previous to boiling; they are wrought in this for about twenty minutes after boiling; the exact time of taking them out must be judged according to the shade wanted.

With this, as with all other colors, there are considerable differences in their proportions; some prefer weaker decoctions and longer time; others vary the quantity of sumac only; some the strength of spirits and the quantity of barwood; but in all fancy colors, *weak solutions and long time very seldom give clear bright colors*, the goods appearing as if partially worn. Barwood red, when dyed as above described, is a beautiful, rich color, and is the most *permanent* of all the *fancy* reds.

BRAZIL-WOOD RED.—Brazil-wood possesses like logwood a distinct coloring matter of a fine red hue. Chevreul gives the following process for extracting it in a state of purity :—"Digest the raspings of wood in water† till all the

* See chapter I. of this Part, article *Barwood Red Spirits*.

† Hellot recommends to use the hardest water, but it should be remarked that this water deepens the color in proportion to the earthy salts which it contains.—See chapter II. of this Part, article *Purity of Water*.

coloring matter is dissolved, and evaporate the infusion to dryness to get rid of a little acetic acid (vinegar) which it contains. Dissolve the residue in water, and agitate the solution with litharge to get rid of a little fixed acid which it contains. Evaporate again to dryness, digest the residue in alcohol, filter and evaporate to drive off the alcohol. Dilute the residual matter with water, and add to the liquid a solution of glue, till all the tannin which it contains is precipitated; filter again and evaporate to dryness, and digest the residue in alcohol, which will leave undissolved any excess of glue which may have been added. This last alcoholic solution, being evaporated to dryness, leaves *brezilin*, the coloring matter of the wood, in a state of considerable purity."

Brezilin is very soluble both in water and alcohol, but from the hardness of the wood the coloring matter is not completely extracted except by boiling. The decoction when boiled has a deep red color, but passes into a rich yellow red by standing. Acids give this solution a yellowish color, but render it unfit for dyeing operations. The following facts may prove useful:—

1. Alkalies	a violet color, fugitive.
2. Protosulphate of iron (copperas) .	a dark purple, not changed by standing.
3. Persulphate of iron	a blackish brown, permanent.
4. Chloride of tin	a deep crimson.
5. Chloride of tin with warmed liquor .	a deep red precipitate.
6. Acetate of copper	a dark purple.
7. The nitrates of the metals	a dirty yellow, destroying red.
8. The salts of potash, soda, and ammonia	a rose color, which soon passes away.
9. Alum	a bulky red precipitate.

Alum and the *chloride of tin*, are considered the proper mordants for Brazil-wood; but all the colors obtained by this wood are, unfortunately, exceedingly fugitive, losing their brilliancy on a short exposure to the air. The sun has a very powerful influence upon colors dyed by this wood, causing them to assume a blackish tint, which changes to a brown, and fades away to a light dun. These changes are supposed to be owing to the coloring matter being decomposed

into water or some other volatile substance, leaving a part of the carbon free, which produces the black; but heat is also destructive to this color; nevertheless, the consumption of Brazil-wood is very great, especially for dyeing what is termed *fancy* reds.

PROCESSES OF DYEING BRAZIL-WOOD RED.—The process practiced by the best English and Scotch dyers, at the present moment, for producing what is termed *fancy* red upon cotton, is as follows:—

1. The cloth being well cleansed from grease or oil, is put into a hot decoction of sumac, made by boiling half a pound of sumac to the gallon of water, and allowing it to steep in this till the solution becomes cold, or about twelve hours.

2. The cloth is now put into the spirit bath or solution of tin,* at the strength of about 4° Twaddell, and kept moving in this solution for about half an hour, or until it assumes a lemon-yellow color.

3. The goods are now washed, until the water passing from them does not taste acid.

4. The cloth is now worked through a decoction of Brazil-wood, in the proportion of half a pound of wood to the gallon of water. After being kept moving through this for twenty minutes, the goods are taken out, and a little alum, in solution, added as *raising*. The cloth is again wrought in this for five or ten minutes, washed well in cold water, and dried.

5. If a rich yellow tint of red is wanted, a little of the decoction of quercitron should be added to the Brazil-wood, before the goods are first entered.—(See chapter III., Part I., articles *Brazil-wood* and *Barwood*.)

All these manipulations are to be performed consecutively, and in the order above given.†

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* See chapter I. of this Part, article, *Brazil-wood Red Spirits*.

† Dingler has endeavored to separate the coloring matter of the different sorts of Brazil-wood, so as to obtain the same tint from the coarser as from the best Pernambuco. His process consists in treating the wood with hot water or steam, in concentrating the decoction so as to obtain 14 or 15 pounds of it from 4 pounds of wood, allowing it to cool, and pouring into it two pounds of skim milk; agita-

SAFFLOWER PINK.—To dye cotton pink with this substance, the liquor may be used as extracted from the vegetable; the goods require no previous preparation, except being well bleached. The quantity of liquor used varies according to the shade required; one pound of safflower to the pound of goods, gives a dark rose; and the other shades in the same proportion. The manipulations are as follows:—

1. The goods are wrought in the alkaline solution for five or six minutes; then taken out, and vitriol added until the solution tastes decidedly sour; the goods are again immersed and kept working in this till it becomes perfectly exhausted. Exhaustion is known by the operator holding a little in a phial, between him and the light; if there is no tinge of red, the solution is spent.

2. The goods should now be well washed, by passing them through three or four tubfuls, and are finished by passing them through sour water with tartar.

It must be borne in mind that, in dyeing with safflower, the water must be pure and always cold; as a very little heat destroys the beauty of the color; they must also be dried cold, and preserved carefully from sunshine. The colors obtained by safflower are the prettiest that can be had upon cotton, but, unfortunately, they are extremely *fugitive*. The most beautiful lilacs, puces, and lavenders, are obtained by safflower and Prussian blue; but it is one of the most difficult colors to produce.*

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ting, then boiling for a few minutes, and filtering. The dun coloring matters are precipitated by the coagulation of the caseous substance. For dyeing, the decoctions must be diluted with water; for printing they must be concentrated, so that four pounds of wood shall furnish only 5 or 6 pounds of decoction. The liquor may be thickened in the ordinary way. A slight fermentation is said to improve the color of these decoctions; some ground wood is put into the decoction to favor this process.

* See chapter V., Part III., article *Safflower and Prussian Blue.*

CHAPTER IV.

OF YELLOW.

PROCESSES OF DYEING YELLOW ON COTTON.

Preliminary observations—Splendid new Processes of Dyeing Yellow on Cotton—Lemon-Yellow—Ambers—Precautions to be observed—Absurd notions of Dyers generally—Their deficiency in Chemical knowledge—Theory and Practice of Dyeing—Various experiments—Yellow with Weld and Quercitron—Opinions of Authors upon Dyeing with these substances.

Preliminary observations.—Yellow is the primary color that, in the natural scale, occurs between red and the active principle of pure light; and is consequently the brightest in the solar spectrum, and the lightest and most delicate of the primary colors. In the neutral gray, its power is therefore greater than that of the other two, being more allied to light.

In artificial light, the purest yellow loses much of its intensity, and can scarcely be distinguished from white. This arises from such lights being generally of a yellow tone, and consequently diffusing this color over all objects within their influence. In daylight its effect is that of gaiety approaching to gaudiness, and its predominance is generally offensive to the eye.

There is no color that requires more management than yellow in colored manufactures. This color is almost always employed in its purest and brightest hues; while the other colors which, according to their relative powers, ought to predominate in intensity, are very generally much inferior. Whether this proceeds from the ease with which it is produced in dyeing, or from a desire to produce a striking effect, we know not; but its abuse in this way must be apparent to all people of taste who have paid any attention to the

matter. It is, however, in its various tints and combinations, of the greatest value in producing brilliancy and richness.

Yellow combines with red in the production of orange color, and with blue in that of green, which colors are its melodising tones. Its contrasting color is purple, resulting from the combination of the other two primaries (red and blue). The hue in which yellow predominates is called citrine, a compound of orange color and green.

Yellow is the most powerful of the positive colors, and consequently the least agreeable to the eye, when unaccompanied, or when predominating in a pure state. Being the lightest of positive colors, this color, next to white, forms the most powerful contrast to black. There are *fourteen* varieties of yellow enumerated in Syme's Nomenclature: but what is here meant by yellow is the color of the yellow jasmyn, or deepest hue of lemon. Yellow, of course, forms a component part of all the tertiary or neutral hues, either in predominance or of subordination.

In the vegetable kingdom, yellow is exhibited in great purity, and in much variety of tint in many flowers. Amongst animals, it often occurs in the plumage of birds, and sometimes in the furs of animals and scales of fishes.

The admixture of red alters its tone towards warmth, but does not very apparently change its character until it approaches orange color; hence many mixtures of this kind are improperly called yellow. But from its alliance to light, and from blue being allied to darkness, the smallest admixture of that color changes it to a greenish tone, thereby effectually changing its character.

In the mineral kingdom, sulphur is probably the only opaque natural substance that approaches to pure yellow; and some of the topazes give this color translucently, although generally tinged with brownish red.

The pigments used in art, are, for the most part, the product of minerals (see mineral colors), amongst which the chromate of lead, called chrome yellow, is the purest.

PROCESSES OF DYEING YELLOW.—The salts of lead and chromium, have completely superseded the use of

vegetable dye-stuffs for the dyeing of yellows, oranges, and most kinds of greens upon cotton. To dye a yellow, the goods are immersed or wrought through a solution of nitrate or acetate of lead, or more generally, a mixture of these, after which the solution is wrung tightly out, and the goods passed through a solution of bichromate of potash, then passed again through the lead solution, and washed and dried. The proportions of the two salts vary according to the particular hue and depth of color wanted, and for deep shades the goods are passed several times through *lead* and *chrome*. The proportions now used in the best English, Scotch, and French dye-houses are, for a lemon-yellow, as follows:—

10 lbs. of cotton, 4 oz. of nitrate of lead, 12 oz. of sugar of lead, and 6 oz. of chrome.

If the shade is to be a little darker, give the following proportions of ingredients:—

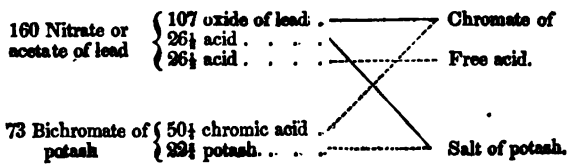
5 oz. nitrate of lead, and 11 oz. acetate or sugar of lead, and 6½ oz. of bichromate.

A very red shade of yellow requires the following proportions:—

8 oz. nitrate and 8 oz. acetate of lead, with 14 oz. of chrome.

When dark *ambers* are wanted, the proportion of nitrate to the acetate of lead is increased, but the last is the highest proportion of bichromate to the quantity of lead, and we need hardly say that anything over is wasted. The proper proportion for dyeing yellow, even were the salts of lead entirely absorbed by the goods, is as near as possible *one-half of bichromate of potash to the lead*, whether nitrate or acetate be used. All above that is direct loss, and as the salt of lead is never all taken up by the goods, the proportion of chrome may be less than half the weight of lead used. However, it may be said that *practice* has dictated these quantities, and the results of practice are more to be relied upon than *theory*. Whether then, is the theory or practice in this case at fault? It will be observed *that the depth of redness of the shade is in proportion to the amount of nitrate of lead used, and that it is the oxide of lead in the acid which gives the dye with the chrome acid of the bichromate of*

potash. Now every 100 ounces of nitrate of lead contains about 67½ ounces of oxide of lead, and every 100 ounces of acetate of lead contains about 68½ ounces of oxide of lead; hence the same weight of acetate of lead should give a richer dye, and take up in proportion a little more bichromate of potash than the nitrate, *so that the practice of giving more bichromate of potash with nitrate of lead must be an error.* It appears that the extra quantity is given for the purpose of reddening the hue of the yellow. How this is effected will be seen presently, when a piece of cloth is put into acetate or nitrate of lead. The cloth is merely soaked with the salt, there is no fixing of the oxide upon it; and if put through water, it would be completely washed off. In this state, therefore, the salt cannot form a dye, it must be rendered insoluble. This is effected, as we have observed above, *by immediate transposition from the salt of lead into the bichromate of potash, where there is formed the insoluble chromate of lead.* That portion of the salt which obtains within the hollow fibres of the cotton becomes fixed, but all that is upon the goods external to the fibres is loose, and either falls off in the chrome tub or is washed off after. This portion probably constitutes one half, creating so much loss; and it is well known that where chrome yellow dyes are produced to a great extent, the chromate of lead thus formed is collected, amounting in a short time to hundred weights, and sold at a trifle to painters. But there is another evil attending this method. Say 100 lbs. of yarn is to be dyed *a red shade of lemon*, this will take 160 ounces of the salt of lead, which will contain 53 ounces of acid and 107 oxide of lead. If we suppose that all the lead salt is taken up by the goods, which is seldom the case, the 160 ounces should take only 73 ounces of bichromate of potash, though in practice they take 140 of bichromate. Now what is the result?



leaving 67 of bichromate of potash to be acted upon by the free acid for the purpose of giving a red shade. Surely something cheaper might be had.

The deleterious effects of free nitric acid in the chrome will be evident by adding a few drops of nitric acid to a strong solution of bichromate of potash; the color remains unchanged. Dip a piece of white paper in this, and it takes a dark orange: expose it to the air, and in 15 minutes the color will have entirely disappeared. A similar change is effected upon the goods with the bichromate upon them when taken out of the tub, and exposed to the air previous to being passed through the solution of lead.

All these evils might be obviated by a little attention to *principles*. We have said that it is the oxide of lead which forms the dye with the chromic acid. This oxide is insoluble, and could be fixed in this state in the goods previous to immersion into the chrome tub. It could be better effected by passing the goods from the solution of lead, through a tub full of water, in which is dissolved a small quantity of soda or potash; this takes up the acid of the lead salt and leaves the insoluble oxide in the fibre. If this be put through the bichromate of potash, it gives a very dull yellow, as the affinity of the chromic acid for the lead is prevented from exercising its power by the potash which is in union with it; but if, previous to putting in the goods, a few drops of sulphuric acid be added to the chrome solution, the chrome acid is set free, and combines freely with the oxide of lead upon the cloth, giving a beautiful yellow. If a red shade be wanted, a little exposure to the air before finishing from the lead will effect it, and a saving will be made.—For further information on these subjects, see *Mineral Coloring Substances*, chapter IV. Part I., also *Calico Printing*, Part VI.

YELLOW WITH WELD.—For a full color of bright greenish yellow, use weld, and proceed as follows:—1. Prepare in a bath of four ounces to the pound of alum and half an ounce of blue vitriol, by boiling the cloth or yarn in it for an hour, and letting it remain in the liquor till cold. Now drain and wring out. 2. The goods should be now run

through sheep's dung liquor at a heat of 120° at the utmost, using a pint of dung, and half an ounce of pearlash, to the pound of goods. Wring out slightly and let them remain in this wrung and slightly moist state, for twenty-four hours. 2. Prepare a dye bath of a pound and a quarter to a pound and a half of weld and two ounces quercitron to the pound of goods, by boiling the weld and bark in a sufficient quantity of water for two hours; then take out the bundles of weld, and strain the liquor. Enter the goods when the liquor is warm, and bring it up to a scald, at which heat continue the dyeing, till the color is exhausted or the required shade is obtained. This color may be enlivened by boiling for half an hour in an ounce of white soap to the pound of goods.

The shade of yellow may be altered by omitting the blue vitriol or blue copperas, by diminishing the alum, and by adding an ounce of pearlash per pound of goods to the weld liquor. When quercitron bark is used instead of weld, Bancroft prescribes at the utmost but eighteen pounds of bark to one hundred pounds of cloth, or of yarn. The quercitron we know goes far in point of color, but it must be very choice to produce a full color with a quantity so small. If for eighteen pounds we read twenty-five, we do not think there will be reason to complain of the alteration. The preparation or mordanting, may go on as above directed in the case of weld. But the cloth or cotton, he says, should be entered in the dye bath when cold, and the heat brought up gradually, and a boiling heat should not be used for more than five minutes, as it is apt to brown the color; which is correct. He is of opinion, with Chaptal, that a small quantity of lime added to the quercitron bath improves the color. He also recommends as an aluminous mordant, the acetate of alumina to be substituted instead of the sulphate of alumine or common alum.*—(See *Mordants*, chapter I. of this Part, article *Alum*.)

* In this Bancroft is perfectly right, as we have shown in the chapter above referred to.

We say nothing in this place, about dyeing cotton yellow with the numerous tribe of yellow drugs that are mentioned in the books of the day, because, as already stated, the salts of lead and chromium have completely superseded the use of vegetable dye-stuffs for the dyeing of yellows, oranges, and most kinds of greens upon cotton. For the common yellows, weld and quercitron answer every purpose. We know that fustic, hickory, barbary-root, golden-rod, yellow-broom, poplar, and many others may be employed for yellows; but a dyer of the common colors, needs only weld and quercitron bark.

CHAPTER V.

OF BLUE.

PROCESSES OF DYEING BLUE ON COTTON.

Preliminary observations—Preparation of Chemic, or Solution of Indigo—Mistaken notions of Dyers and Authors upon this subject—Chemistry of the Blue-Vat—Setting the Vat—Sulphate of Iron, Impurities of—Erroneous opinions of Dyers upon this subject—Effect of impure Copperas, or Sulphate of Iron, in the Vat—Prussiate of Potash—Processes of Dyeing Prussian Blue—Dyeing of Lilacs, Puces, Lavenders, &c.

Preliminary observations.—Blue is the third of the primary colors, and belongs more to the principle of darkness or shade than either of the other two (red and yellow), and it is consequently the most retiring of the three. It is also of these elements the most cool and pleasing to the eye, associating, as it does, with the groundwork of the retina itself. It imparts to every hue of which it forms a constituent, a cooling and retiring quality, and enters into combination with yellow in the production of green, and with red in that of purple, which are consequently its melodizing colors. The contrasting color to blue is orange, and the tertiary in which it predominates is olive—a composition of green and purple. Blue is much deteriorated and neutralized in artificial light, and is therefore decidedly a daylight color. Olive, as an individual color, is soft and unassuming, and is of great use in all arrangements, whether cool or warm. But it is in its contrasting powers in the lower notes (to continue the analogy) of warm-toned or brilliant compositions that it is most valuable. It relieves and harmonises, according to its various hues, the tertiaries russet, citron, marone, and brown. Owing, however, to the discord already noticed, it ought never to be brought into immediate contact

with blue; it is absolutely necessary either greatly to reduce the green, or to introduce a semi-tonic color between them. This color may be a gray of a warm purply hue, and will melodise best in being blended with the blue, and produce harmony in coming distinctly against the olive in its full warmth. Slate-color is the next hue in the progress of blue down to black, which, from its peculiar nature, cannot be used in any but cool-toned arrangements.

Blue is individually a pleasing, and, at the same time, a brilliant color. It may, therefore, be used in any general arrangement of colors, as it is in the coloring of nature, in a much larger proportion than either of the other two primaries (red and yellow). As a leading color in decoration, it is extremely beautiful when in its proper place. For instance, in the drawing-room of a summer residence, especially when lighted from the south, its effect as an archeus or key is cool and refreshing, as also in bed-rooms of the same description. In all *variously-colored* manufactures of *silk*, pure blue, when properly introduced, is both sparkling and pleasing; but in worsted manufactures, its shades and tints are the most useful. Pale tints of blue, or any other color, should never be introduced into warm arrangements. In such cases it ought always to be used in its deepest hues and shades. This should be particularly attended to *by designers of patterns for manufactures*, for the indiscriminate introduction of light cool tints *is a prevailing error amongst them*. It has already been explained, that warm colors are naturally allied to light, and cool colors to shade. Light tints are, therefore, when employed in such designs, enhanced and strengthened by being of a warm tone, and are consequently neutralised and sunk as they approach to that which is cool.

Blue, like the other two primary colors (red and yellow), occurs in great purity in some flowers, in the plumage of some birds, and even in portions of the skin of some beasts. But it is found less frequently in the vegetable and animal kingdoms than either red or yellow.

Amongst minerals, the *lapis lazuli* presents the purest

blue that can be conceived, and is converted by a very simple process into an equally beautiful pigment.—(See Appendix, article *Lazulite*).

PREPARATION OF CHEMIC.—The only substance which dissolves indigo,* without destroying its color and composition, is highly concentrated sulphuric acid. For this purpose, the fuming acid of Nordhausen is preferable. The substance formed is popularly known by the name of sulphate of indigo, Saxon blue, China blue, and extract of indigo. The action of sulphuric acid upon indigo is found to be something more than a mere solution: a chemical combination, in definite proportions, results, forming two distinct substances, differing considerably from each other in their properties. These two compounds were discovered and described by Mr. Crum, and called by him *cerulin* and *phinacin*, from their colors—the former blue, and the latter purple. They have been since named sulph-indylic acid, and sulpho-purpuric acid. The former, which constitutes the blue principle of Saxon blue, is formed most abundantly when the sulphuric acid is sufficiently strong and abundant, and other proper means, to be noticed, attended to. Its composition is found to be one atom of indigo combined with two of sulphuric acid. The other is the principal product when the indigo preponderates. It is of a purple color; and when the solution is diluted with water, it precipitates. Its composition is found, from experience, to be equal to one atom sulphuric acid to one of indigo.

From the nature and properties of these two substances, it is evident that every care should be taken to convert the indigo into sulph-indylic acid, and to avoid the formation of sulpho-purpuric acid. The circumstances under which this latter acid is formed are—first, too little acid, in proportion to the indigo. The general proportions used by dyers vary from *three* to *five* pounds of acid to *one* pound of indigo. This is by far too little, and occasions a considerable loss of indigo by

* For the cultivation, properties, and manufacture of Indigo, see chapter III., Part I., article *Indigo*.

the precipitation of the sulpho-purpuric acid, when the solution is mixed with water. Close observation shows that it requires from *six* to *eight* pounds of the fuming sulphuric acid to convert a pound of indigo into blue sulph-indylic acid, and will require from eight to ten of the strongest English sulphuric acid to give the same results.* From some investigation lately made by M. Dumas, an eminent French chemist, indigo requires even a larger proportion of acid to convert it into sulph-indylic acid. He recommends no less than *fifteen* parts of acid to *one* of indigo. This quantity, however, would be very annoying where it is all to be precipitated by lime.

Another circumstance under which sulpho-purpuric acid is formed, is, too short time being given for the indigo and acid to digest. When indigo is first put into the sulphuric acid, there seems to be an immediate solution; but if a drop be spread upon a window pane, *it appears of a dirty green color*. If this be allowed to stand for a little upon the glass, a yellowish-colored liquid begins to run from the blue mass, occasioned, no doubt, by the acid absorbing moisture, and separating itself from the indigo, and clearly showing that the change upon the indigo by the acid is not an immediate effect. The more impure the indigo, *the darker and greener appears the substance when put upon the glass*. After the mixture has stood two or three hours, and is tried in the same manner, it will appear of a reddish purple color,—the principal compound existing now in the solution being sulpho-purpuric acid. As the liquid stands, it begins to assume a violet shade, and finally passes to a deep rich blue. But dyers seldom obtain it in this state: in their hands it generally has a reddish tinge. Mr. Crum found that when the solution is diluted with water, after the color has become of a bottle-

* According to Dr. Ure, "eight pounds of the common oil of vitriol, are necessary to dissolve one pound of indigo," but observes, "that four pounds of the smoking acid, may *possibly* effect the purpose." If Dr. Ure perfectly understands this subject, as he says, in the preface of his Dictionary, he does, why does he not give us the exact results of his practical experience, instead of *theory*? We want positive information.

green, the action of the acid is stopped, and sulpho-purpuric acid only is formed. But there are other means by which the action of sulphuric acid upon indigo may be stopped, than by directly diluting the solution with water. As already intimated it is only the highly concentrated sulphuric acid which converts indigo into sulph-indylic acid. Now, dyers not unfrequently alter the strength of their acid, by the process of mixing and preparing their *chemic.** This is very generally done in an open, wide-mouthed vessel, which is allowed to stand uncovered, probably in the midst of the steam and vapors of the dye-house; or, in some cases, the vessel is put into a boiler, or tub, with warm water.† By these injudicious means, the sulphuric acid, which absorbs water very rapidly, *is diluted below the necessary strength for dissolving indigo;* and the result is, *the formation of sulpho-purpuric acid* instead *of sulph-indylic acid*, which is the real substance wanted.‡

Another cause of the stopping of the action of the acid by dilution is, from the indigo. Ground indigo absorbs a quantity of moisture; and if it be not thoroughly dried previous to putting it in the acid, the acid is too much weakened to effect the formation of the substance required.

There are other causes by which the preparation of *chemic* is injured. Sometimes the acid and indigo are mixed together at once, and by this means the heat evolved is sufficient to decompose the impurities of the indigo. Part of the acid also suffers decomposition, and a great quantity of sulphurous acid gas is given off,—so much, indeed, that the

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* The technical name for sulphate of indigo.

† Mr. Partridge, in his book on dyeing, page 23, tells us that "*Chemic* should be made in glass or stone-ware pots. Common earthen-ware will not answer, for the oil of vitriol dissolves the glazing. The compound may be made either in *a sand heat*, or in *warm water*." We hope no American dyer has been foolish enough to follow these directions.—(See chapter II. Part III., article *Purity of Water*.)

‡ "The acid," says Dr. Ure, "is to be poured into an earthen pan, which, in summer, *must be placed in a tub of cold water to prevent it getting hot*, and the indigo, in fine powder, is to be added, with careful stirring, in small successive portions. *If it becomes at all heated, a part of the indigo is decomposed with the disengagement of sulphurous acid gas, and indigo green is produced.*"

head cannot be held above the vessel for any length of time without injury. Another practice is—for the sake of quickening the operation—to place the vessel upon the flue in the stove, and keep the solution for hours at a heat upwards of 300° F. The gas given off in these cases is sometimes so great as to destroy the colors of goods hanging in the stove. Indigo submitted to such treatment is seldom found good: often its appearance on the glass (which is a general method of testing the quality of sulphate of indigo,)—is a blackish green—sometimes a dirty purple—seldom the fine blue violet —scarcely ever the beautiful blue.

Although the sulpho-purpuric acid is precipitated when water is mixed with the solution of sulphate of indigo, and is insoluble in dilute acids, it is, when freed from the sulphuric acid, soluble in distilled water; but if any substance be in the water—*and common spring water is never pure*,*—it is less soluble. It dissolves in alkalies, and in solutions of the alkaline earths, giving a blue color, of greater or less purity, according to the nature of the solvent.

We have found the following method of preparing sulphate of indigo, in quantities for use, very satisfactory:—

The indigo is reduced to an impalpable powder, either by grinding in a mortar or a mill, and completely dried, by placing it upon a sand bath or flue for some hours, at a temperature of about 140° or 150° F. For each pound of indigo, ten pounds of highly concentrated sulphuric acid are put into a large jar, or earthen pot, furnished with a cover. This is kept in as dry a place as possible, and the indigo is added gradually, in small quantities. The vessel is kept closely covered, and care taken that the heat of the solution does not exceed 212° F. When the indigo is all added, the vessel is placed in such a situation, that the heat may be kept at about 150° F., and allowed to stand, stirring occasionally, for forty-eight hours. These precautions being attended to, we have uniformly found that any failure occurring, was clearly traceable to the impurity of the indigo, or weakness of the acid used.†

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* See chapter II. of this Part, article *Purity of Water*.

† Chemic-blue is used for various operations in dyeing. When diluted with twenty times its quantity of boiling water, and allowed to settle, it is sometimes used for dyeing colors upon *wool* and *silk*—especially for greens upon the latter substance. A little carbonate of potash is added, by some, with the boiling water, and the clean solution used as above. When fine light shades, such as sky-blue &c., are wanted, this diluted liquor is boiled or digested with a piece of woolen.

We have already mentioned that indigo is insoluble, except in strong sulphuric acid;* but if it be by any means deprived of an atom of oxygen (according to the common theory,) it is soluble in alkalies. It may be said that, according to the law of definite proportions already described, it cannot be indigo with an atom less of oxygen. Neither is it; and we see that it has different properties from common indigo, for it is soluble even in weak alkalies; has a powerful attraction for oxygen; and is of a white color. This substance has been termed *indigogen*, and it may be observed, that the nature of the blue vat depends upon the introduction of substances capable of extracting oxygen from the indigo, and converting it into *indigogen*. The substances generally used for this conversion are the protoxides of iron and tin, orpiment (sulphuret of arsenic), and organic substances. These last produce the desired effect by their decomposition, such as in the woad vat, where, by the fermentation of the woad and madder, the oxygen is extracted from the indigo which is thus converted into indigogen. The indigogen is dissolved as it forms, by the potash put into the vat.†

CHEMISTRY OF THE BLUE VAT.—What is termed the common blue vat, or lime vat, is made up with indigo, lime, and sulphate of iron (copperas). But before describing the nature of this vat, it will be necessary to say something upon the nature and properties of the oxides and salts of iron. Iron combines with oxygen in two different proportions.‡

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cloth, which takes up the blue color; what remains is a greenish-colored substance, probably the impurites of the indigo. The cloth is washed with cold water, and kept for use. When light shades are to be dyed, this cloth is put through hot water, which extracts a quantity of the blue. When warm water ceases to extract enough, a very minute quantity of a carbonated alkali is added, which bleeds, as dyers term it, the color from the cloth.—See Part IV.

* Although we have described the action of sulphuric acid upon indigo to be something different from *solution*, we use the term for convenience.

† The method of preparing chemic for dyeing green upon light cotton goods, is detailed in chapter VII. of this Part, and to which the reader is referred.

‡ There has been a new oxide of iron discovered lately by M. Fremy. This oxide is obtained by igniting a mixture of potash and peroxide of iron; a brown mass is the result, which, by digestion in water, gives a beautiful violet-red colored

The first of these combinations is one atom oxygen with one atom iron: this is termed the first or protoxide. The second oxide consists of three atoms oxygen to two atoms iron; this is termed the peroxide, and is the highest oxide recognised by chemists. The first of these, namely the protoxide, has such a strong attraction for oxygen, that it is nearly unknown in a pure state; but it exists in combination with some acids, such as sulphuric acid, forming the sulphate of the protoxide of iron. When this acid is neutralized by an alkaline substance, so that the oxide is set at liberty, it immediately begins to absorb oxygen, and passes into a peroxide. This property of the protoxide of iron being kept in mind, it will enable us to explain the theory of the blue vat. When finely ground indigo is put into a vat with a mixture of lime and sulphate of iron, the first action which takes place is the decomposition of the metallic salt;* the acid, which is in union with the protoxide of iron, combining with a portion of the lime, forming sulphate of lime. The detached oxide of iron extracts more oxygen from the indigo, converting it into indigogen; and the peroxide of iron thus formed, and the sulphate of lime precipitate, forming what is termed *sludge*. The remaining portion of lime seizes the indigogen, and forms with it the solution required. The following diagram represents this action and the results more clearly, and may be called the theory of the blue vat:—

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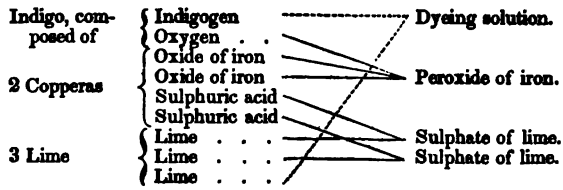
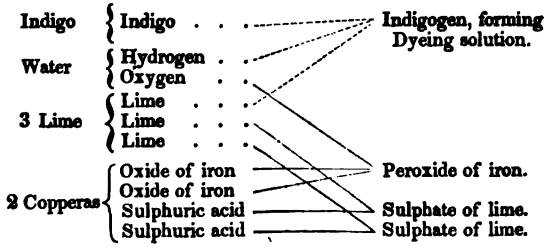
solution. The compound is very soluble in water. A large quantity of water decomposes it in course of time. But it becomes insoluble in very alkaline water, forming a brown precipitate, which readily dissolves in pure water, and affords a fine purple-colored solution. A temperature of 212° dissolves it immediately; all organic substances decompose it; and hence, it is impossible to filter the solution. It is impossible to isolate this compound, for when the red solution is treated by an acid as soon as the potash is saturated, oxygen is disengaged, and peroxide of iron precipitated. If the acid be in excess, it dissolves the peroxide, and gives rise to the formation of a peroxide salt of iron. It is said it possesses a powerful dyeing principle.

* By the successive immersions in milk of lime and solution of sulphate of iron, protoxide of iron comes to be precipitated on the surface of the cloth. This protoxide of iron, with the assistance of the lime, reacts on the indigo imprinted on the calico, through the intervention of water, into indigotin, which dissolves in the lime-water, and the solution is absorbed into the pores of the cloth.



It will be observed, that the theory of the blue vat depends upon the supposition, that indigogen is indigo, with an atom less oxygen; but M. Dumas, from the results of some analysis which he made upon indigo, considers indigogen to be the blue indigo, in combination with hydrogen. According to this view of the composition of indigogen, the action which takes place in the vat will be a little different from that given above. When the lime combines with the acid of the copperas, the iron decomposes a portion of water combining with the oxygen, and the hydrogen combines with the indigo forming indigogen, which may be represented as follows:—



The theory is equally, if not more beautiful, than the former, but in some cases it is scarcely equally reconcilable with our chemical experience. When the goods are put into the vat, the dissolved indigogen combines with them, and when brought into contact with the air, according to the former theory, the indigogen combines with oxygen, for which it has a strong disposition, and blue indigo is formed, and remains combined with the cloth; but according to the latter theory, the blue indigo is left in combination with the cloth by the hydrogen combining with the oxygen of the atmosphere, forming water. That hydrogen should combine with the free oxygen of the air, and form water so rapidly under such cir-

cumstances as mere exposure, is somewhat anomalous, but this is no reason for rejecting it. If a mixture of copperas and lime be put into a bottle with distilled water, the water is not decomposed; the lime combines with the acid, which, along with the iron, is precipitated, and if the air be completely excluded, the iron remains as a protoxide for days; indeed, the change from a protoxide to a peroxide, is so slow that a long time elapses before it is appreciable; but if indigo be added, even after the mixture has stood for some time, the action of the common vat proceeds. This, according to Dumas' theory, gives a beautiful illustration of relative affinities. Before the indigo is introduced, the attraction of the iron for oxygen is about equal to that of the hydrogen, which holds it in combination as water; but when the indigo is introduced, although its attraction for hydrogen must be very weak, as it requires the nicest management to get that compound isolated; still it is sufficient to disturb that equilibrium with which the oxygen was held by the iron and hydrogen, giving the former the mastery. Whether the presence of an alkaline substance has any effect of inducing, if we be allowed the term, the formation of indigogen, we cannot pretend to determine; but it is never formed in the vat without the presence of some alkaline substance, which dissolves it the moment it is formed.

SULPHATE OF IRON.—As the sulphate of iron (copperas) is the general deoxidising agent used, *and there being a good deal of prejudice amongst our brethren respecting the proper qualities of that substance*, we shall offer a few suggestions upon the proper choice of copperas. If a piece of iron be put into dilute sulphuric acid, it dissolves with the evolution of hydrogen gas. This solution being evaporated till a pellicle or sort of skin appears on its surface, and set aside to cool, a great quantity of green colored crystals are deposited. These crystals are copperas; but the greater part of sulphate of iron used in the arts is prepared by a different process. Sulphuret of iron, or iron pyrites, is a mineral found very abundantly in some places in the coal measures, along with coaly matter and clay. When these materials are ex-

posed to the action of the atmosphere and moisture, the pyrites absorbs oxygen, and the sulphur becomes converted into sulphuric acid; this attacks the iron, and also the alumina of the clay. These sulphates are dissolved with water, which drains through into beds prepared for the purpose, and the liquor is afterwards evaporated to the proper extent, so as to allow the sulphate of iron to crystalize.* Iron is sometimes added to the solution, which takes up any free acid and separates some impurities such as copper. By adding sulphate of potash to the supernatant liquor, alum is formed. Sulphate of iron is found to be composed of one proportion of sulphuric acid, and one of oxide of iron, and crystalizes with seven atoms of water. It loses six of these atoms of water if exposed to a heat of 238° Fah. This is the description generally given *in chemical books* of this salt; but the dyers know from experience, that there are varieties of copperas, whatever may constitute the difference of composition. Bandsdorff in the *Records of Science*, states, "that there are three varieties of the protosulphate of iron; the first greenish blue, formed from an acid solution free from peroxide; the second dirty green, from a neutral solution without peroxide; and the last emerald green, from a solution impregnated with peroxide salt." This we know *by experience* to be correct—that answering the description of his second variety being the best for general use. The selection of this particular quality of copperas has led dyers into a fatal prejudice. Sulphate of iron crystalized from a neutral solution, if kept any time assumes a rusty appearance by absorbing oxygen, and converting the iron into a peroxide. Now, good copperas having generally this appearance, especially on the surface of the cask when opened, dyers, most of them, *are of the opinion that it is to this redness it owes its superior quality.* But from the description already given of the nature of the vat, it will be obvious that all that is red is useless, nay worse, for it

* English copperas is often prepared from pyrites. Where there is no clay present, the excess of acid is taken up by adding iron.—(See chapter I., Part III., article *Iron*.

adds to the sediment in the vat. And, besides this, Parkes mentions in his chemical essays, that some unprincipled dealers take advantage of this prejudice of the dyers, to sprinkle powdered lime on the top of the cask to peroxidise the surface, *and make them believe that they have got a lot of excellent old copperas.*

It may still be inquired what constitutes the difference of these varieties of the sulphate of iron alluded to? We are sorry to say that we cannot give a decided answer to this inquiry, but will merely mention the results *of our own experience* relative to the question, and which are as follows:—

1. Our first method for ascertaining the real value of copperas, was by taking a weighed quantity, generally twenty grains, of the salt, dissolving it in distilled water; boiling the solution, with the addition of a few drops of pure nitric acid, to peroxidise the iron which was precipitated by adding an excess of ammonia. The precipitate was placed upon a filter, thoroughly washed and dried. The peroxide of iron was then carefully weighed, and noted. The average results of these trials were as 21 to 24, that is 21 pounds of *good old copperas*, as dyers term it, were equal to 24 pounds of new copperas.

These results correspond with the practical effects experienced in working the vats; but the mere extra quantity of copperas, necessary to keep the vats in working condition, when this bad stuff is used, is not the worst. It is also necessary, under these circumstances, to add an extra quantity of lime, which, in technical language, causes the vats to *swim;* that is, the precipitate swims, and is long in settling to the bottom—the goods come in contact with it, and the color is deadened. Under this emergency the dyer uses a little carbonate of soda or potash, which forms soluble salts, and causes no extra precipitation. In order to ascertain the true amount of this evil, the following experiment was made:—

2. A solution of nitrate of barytes was taken in the common alkalimeter, at such a strength that one graduation of the alkalimeter exactly precipitated the acid of one grain of the best copperas.

The average difference found by this method of experimenting, was as 20 to 21; and experience taught that, for every 15 pounds of bad copperas, 2 pounds extra lime had to be added. It was probably the result of such experience

which led dyers to suppose that there was a bisulphate of the protoxide of iron, and to give instructions how to guard against it.* As this watery-looking, whitish, blue, green, copperas, is, according to Bandsdorff, crystalized from an acid solution, it is probable that the extra proportion of acid which is found in it *is owing to a portion of the mother liquor being mechanically combined with the crystals, but not forming an essential ingredient in the composition of the salt.*

It may be observed that the experiments we have detailed, favor the idea of the bad copperas being a bisulphate of iron, seeing that a given weight of the one has less iron and more acid than the same weight of the other. But, it has been already noticed that sulphate of iron crystalizes with seven atoms of water. Is this quantity of water, we would ask, invariable? The green color of the salt depends upon the presence of water, for when deprived of its water it is white; now the colors of the two kinds of copperas referred to are decidedly different, as already described. May it not, therefore, be inferred that the difference of color depends upon different proportions of water present in the crystals, which, if this be the case, will account for the different proportions of iron found in the same weight of the salt? It has been already noticed, that of the seven proportions of water which copperas contains, it loses six at 238°, but it retains one even at 535°:—

3. We took 20 grains of each of the good and bad qualities of copperas, reduced them to coarse powder, and submitted them to a heat of between 350° and 400°, for fifteen minutes; and taking the mean of three experiments, the bad copperas lost 1 1-2 grains more than the other.

Although these results were very satisfactory, in so far as they agree very nearly with our other experiments, and exactly coincide with our *practical experience*, yet, as the results have not been noticed so far as we are aware by chemists who have written upon the subject, it is with some diffidence that we give them publicity, and for the same reason refrain from offering any other remarks on the sub-

* Cooper.

ject than will already be inferred; namely, *that the whitish blue copperas ought to be avoided in dyeing blues by means of the blue vat.*

Before proceeding further we will point out some impurities which occasionally exist in copperas, and which are very hurtful in the blue vat.

IMPURITY OF COPPERAS.—A very common impurity in sulphate of iron (copperas), is sulphate of alumina. The deleterious nature of this salt does not consist in its action upon the indigo, but it introduces to the vat a good portion of sulphuric acid; and as it forms a double salt with the sulphate of iron—which double salt combines with 24 equivalents of water—its presence may account for the various results obtained in the experiments detailed above, with bad copperas, and its evil effects in the vat. It is, no doubt, the presence of sulphate of alumina that renders the Scotch copperas so much inferior to the English. The presence of alumina may be detected by its giving the peroxide of iron, when precipitated, as already described by ammonia and filtered, a very bulky and clayey appearance. If this precipitate be dissolved in muriatic acid, and the iron again precipitated by caustic potash, added in excess, and filtered; the alumina being now in solution, passes through the filter, and may be again precipitated by adding ammonia. It is a bulky white precipitate. The presence of sulphate of zinc and copper may be detected by a similar process—the iron being peroxidized and precipitated by ammonia. If copper be present the supernatant liquor has a blue color; it may also be detected by putting a piece of clean iron in the copperas—the copper is deposited in the metallic state on the iron. If zinc be present, and a stream of sulphureted hydrogen gas passed through the clear filtered liquor, a white precipitate is obtained. This latter substance is very seldom present in copperas. The deleterious effects of these two substances are of the same nature; they hold their oxygen by a comparatively feeble attraction, so that when any deoxidizing substance comes in contact with them they yield their oxygen to it, consequently their presence in the blue vat

neutralizes the effects of the sulphate of iron. It is from this property that these salts are used in resist-work in *calico-printing*,* which is conducted in the following manner:—

A certain preparation, the best we believe, the sulphate of copper or zinc, mixed either with flour paste, with gum, or with pipe-clay and gum, is printed on the calico, of any pattern that may be desired; when this is sufficiently dry, the goods are then dyed in the blue vat, those parts of the piece which are printed with the copper or zinc will not be dyed blue, *because the deoxidised indigo becomes oxygenated the moment it touches the copper, by its yielding its oxygen to the indigo*, and occasions it to become insoluble, *and consequently incapable of forming a dye.*†

THE COMMON BLUE VAT.—For the gratification of such as are not versed in the manipulations of print-works and dye-houses, we would state, that where piece-goods are dyed blue, the vats are necessarily large, being generally about three feet wide by five feet long, and eight feet deep, made of iron, but sometimes of stone,—these are sunk into the ground about half their depth.

The goods to be dyed are stretched upon a frame, when the whole is lowered into the vat. Sometimes these frames are furnished with rollers, when, instead of fixing the piece on hooks, it is passed over these rollers while in the vat, by which means long pieces are dyed perfectly even in color.

The vats for yarn or skein are small, being generally old wine or oil pipes; these are also sunk about half their depth into the ground. Wooden pins are put through the skein, and rest upon the edge of the vat, the skein is then turned over, the one half dipping in the liquor, the other half over the pins. The time of this operation varies according to the strength of the vat. The operation being continued some time, the skein is taken out, wrung, and exposed to the air, dipped again, and so on, by alternately dipping and exposing, till the requisite shade is obtained.

* See *Calico-Printing*, Part VI.

† According to Dumas' theory, the hydrogen, in combination with the indigo, unites with the oxygen of the copper and forms water, and both results are alike.

To prepare the vat, it is filled to within a few inches of the mouth with water, the dyeing ingredients are then added—the proportions given in most chemical books, are 1 part (by weight) indigo, 2 parts sulphate of iron, and 3 lime, but this proportion of lime is too much,* the practical dyer does not consider his vats in good condition when this proportion is used. The following proportions are considered good for preparing one of these small vats, assuming that all the ingredients are good :—

8 pounds of indigo, 14 pounds of copperas, and from 18 to 20 (not above 20) of lime. If the copperas be bad, a pound or even two pounds more of it may be required along with two or three additional pounds of lime, to have the same results. These ingredients being put in, the whole is well stirred every two or three hours during the day, and, after settling for twelve hours, it is ready for use.

PRUSSIATE OF POTASH.—We have on several occasions referred to compound substances which combine with bases, and in other respects act as simple bodies. Such substances are on these accounts termed *salt radicals*. One of the most definite of these is cyanogen, which in its simple state is a gaseous body, and is composed of two of carbon and one of nitrogen. It does not exist in nature, but can be readily formed by bringing its elements together at a high temperature in contact with a base that will unite with it, and will remain in the compound state under the circumstances. Thus, when any organic substance containing nitrogen is calcined with potash, the nitrogen and carbon combine and form cyanogen which unites with the potassium of the potash, and forms cyanide of potassium. This is the condition in which it is generally obtained, and its union with other bases is effected by the decomposition of that compound; as, for instance, if we add a solution of cyanide of potassium to a solution of nitrate of silver, the potassium combines with the nitric acid and the cyanogen with the silver, forming cyanide of silver, a dense white powder. When cyanogen com-

* For *one* pound of indigo *three* pounds of copperas are taken, and *four* pounds of lime. If the copperas be partially peroxidized somewhat more of it must be used. —*Ure*. These proportions will not answer well in practice, as above stated.

bines with hydrogen, which it does with facility, it forms prussic or hydrocyanic acid.

Cyanogen is remarkable for combining with other elements and forming with them compounds which are also definite *salt radicals;* the principal of these is ferrocyanogen which is composed of three of cyanogen and one of iron. The compounds which this *salt radical* forms with other bases are distinguished by the prefix *ferro.* Thus when united with potassium, it forms ferro-cyanide of potassium (prussiate of potash) which is composed of one of ferrocyanogen and two of potassium. The prussiate of potash is prepared on the large scale by calcining together dried blood, hoofs, parings of horns, hides, old woolen rags, or similar material, with carbonate of potash, in an iron vessel; those substances are generally carbonised or burned in large cast iron cylinders previous to being used with the potash. If the animal matters are used without being subjected to this process, they are mixed in the ratio of about 8 to 1 of pearlash; but if burned, one and a half of the charcoal is mixed with one of pearlash. When the animal matters are used without being charred, the calcining pot is left open to allow of the materials being stirred and the noxious vapors to escape; after which the vessel is closed and the heat is increased. This is continued for some time, and at intervals of half an hour, the mouth of the vessel is uncovered for the purpose of stirring the matter within. This process is continued until the flame ceases to rise from the surface, and the materials become a red semifluid mass, which generally takes place about 8 hours after the pot is closed. The molten mass is scooped out with iron ladles, and allowed to cool. The theory of the formation of the yellow prussiate will be easily understood, on referring to what has been said of cyanide of potassium. The material of the iron pot in which the calcination is conducted, though sometimes iron filings are added for the purpose, combines with the cyanogen and forms the salt radical ferrocyanogen, which simultaneously combines with potassium, forming ferrocyanide of potassium. When the mass

is cold it is dissolved in cold water, and the solution is filtered through cloth. Lest any cyanide of potassium should remain which had not received the proportion of iron, sulphate of iron (copperas) is added by degrees to the solution, so long as the Prussian blue, which is at first formed on adding the iron, is redissolved. The whole is then evaporated to a proper consistency; after which, pieces of coarse cord are suspended throughout the liquid, upon which, as nuclei, crystals of ferro-prussiate are formed in regular heaps. They are of a beautiful light citron yellow. From this salt all other ferrocyanides are derived as precipitates; those of the metals are formed by adding a salt of the metal to a solution of the prussiate. The following are the appearances of a few of those precipitates, corresponding to the metals employed:—

Protoxide of Manganese,	White, turning to a deep red.
Peroxide of Manganese,	Greenish gray.
Lead,	White with a yellowish hue.
Peroxide of Iron,	Deep blue.
Protoxide of Iron,	White, turning blue by exposure.
Copper,	Brown.
Zinc,	White.
Protoxide of Tin,	White.
Peroxide of Tin.	Yellow.

Each of these precipitates constitutes the ferrocyanide of the metal used, which has taken the place of the potassium; they are all insoluble in water, and where a color can be obtained by them, they are suitable for a dye, although the colors dyed by the yellow prussiate are fugitive. Every alkaline substance, such as soap, destroys them, and they are easily affected by that universal destroyer of colors, the sun. The principal use of the ferrocyanide salt in the dyehouse, is for dyeing *Prussian blue.*

PROCESSES OF DYEING PRUSSIAN BLUE.—To dye this color, the goods are impregnated with a persalt of iron, and then passed through a solution of prussiate of potash.

Some dyers are in the habit, when dark blue is wanted, of putting the goods, after being tightly wrung from the iron solution, directly into the prussiate solution. We need hardly say that this is waste of stuff, as it requires *triple the quan-*

tity of prussiate. When a dark shade of blue is wanted for yarn, the best method of obtaining it is the following:*—

Pass the yarn from the iron solution through a strong solution of potash, or soda. Being washed well from this, it is put through the prussiate solution; this is the method adopted for dark blues, on printed calicoes; but for fine muslins, and such like, which require to be finished blue, this process does not answer so well, as the goods are generally colored.

Very little cotton yarn is dyed Prussian blue, though an immense quantity *of light piece goods* are done so, requiring careful management to have them equal and all of one hue.

In treating of *Mordants* (chapter I. of this Part,) we have described the method of preparing the solution of iron for the purpose of dyeing Prussian blue, viz., *to dissolve it in nitric acid.* A little of this nitrate of iron is put into a vessel full of water, and well mixed. The cloth is put into this, and wrought as quickly as possible by the process of edgeing:

That is, catching the edge of the piece with the right hand, and lifting it as high as the arm will allow while the left hand is passed down along the edge, till the arms are at full stretch—the left hand retaining its hold of the piece, while the right hand lets it free, the piece spreads out full into the liquid. The left hand is then raised to meet the right, and transfers its hold to it, to go through the same operation. This is performed so rapidly, that a good edger will go round a 20 yard piece half a dozen times in a few minutes, so that the whole surface of the cloth gets equally exposed to the liquor.

Being wrought from ten to fifteen minutes in this manner, in the iron solution, they are washed through two or three tubsfull of clean cold water, which takes off all the superfluous acid and iron. Whether the cause of the reception of the dye be an attraction of the material of the cloth for the iron or the simple power of absorption of the fibres, we shall not stay to examine here; but although the nitrate of iron be an exceedingly soluble salt the peroxide of iron remains fixed in the fibres, having abandoned its acid, *and thus no washing will remove it.* The cloth being well washed from the

* In its present form, this beautiful color has not been long in general use for application to calicoes. The color obtained by the mixture formerly employed, consisting of prussiate of potash with tartaric or sulphuric acid, without any addition of perchloride of tin or alum, is always lighter in shade and less vivid than that obtained with such an addition, however concentrated the solution of prussiate of potash.—*Parnell.*

acid, as has been observed before, it is put into the prussiate; but, as has been observed, unless an acid be added to the prussiate, the goods, being washed and put in, *receive no definite color*, as the potassium which is in union with the ferrocyanogen, prevents it from combining with the iron. A small quantity of sulphuric acid is generally added to the ferrocyanide of potassium solution, to take up the potassium, and to set the ferrocyanogen at liberty, to unite with the iron upon the cloth; *this forms ferrocyanide of iron or Prussian blue*, and constitutes the dye. Considerable care should be taken in adding acid to the prussiate, otherwise the color is liable to change, becoming gray or reddish when dried.

The following mode of adding sulphuric acid to the prussiate, when a considerable quantity of goods are to be dyed at once, is commonly practiced:—

What is considered the proper quantity of yellow prussiate of potash is dissolved in just as much of boiling water as is necessary. To this solution a quantity of sulphuric acid is added, so as to make it strongly acid. The mixture thus prepared is added to the *prussiate tub*, as may be required.

This process for adding the sulphuric acid is exceedingly objectionable, as it causes the evolution of prussic acid, which may be detected by the pungent smell it excites. Now, *in proportion to the escape of that gas will be the loss of the dyeing property of the prussiate.* If three parts of acid be added to seven of yellow prussiate, the loss will amount to one half, while the remaining half would be so changed in its properties as to produce but a bad blue; thus the dyer must use an additional quantity of prussiate, and he produces but an indifferent color.

The proper method of using the acid is to dissolve the prussiate in hot water, and to add the necessary quantity of this to the water-tub in which the goods are to be dyed; previously to putting in the cloth, a few drops of sulphuric acid are added, just sufficient to be perceptible to the taste, or, what is a much better test, sufficient to redden blue litmus paper. The goods being wrought for some time in this mixture, are washed in clean water, having a small quantity of alum in solution. For light shades of *sky-blue*, they should

not be dried from the alum solution, as there is a great tendency to assume a lavender hue. A better plan is to employ two tubs of water, the one being touched with alum, and the other pure for washing from it. Cloths dyed by the prussiate should be exposed to *a very dry atmosphere* when hung up to be dried.

In dyeing blues with yellow prussiate of potash, it is essential that the iron salt employed should be *a persalt*. Hence the reason that nitrate of iron, rather than sulphate, is used. If the iron be dissolved in sulphuric or muriatic acid, it would not yield a blue with yellow prussiate of potash; but if either of these solutions be raised to a boiling heat, and nitric acid added gradually till the red fumes cease to be given off, we would then obtain the *persulphate*, or *permuriate* of iron, and at a much less expense than the nitrate, besides being much better adapted for many light shades of Prussian blue; and far superior for dyeing lavenders, lilacs, &c., with safflower.—(See next article.)

If a current of chlorine gas be passed through a strong solution of yellow prussiate of potash, till the solution changes to a reddish color, and when a drop of it added to nitrate of iron gives no precipitate, there is formed chloride of potassium, and a salt differing materially from yellow prussiate. The solution being evaporated, this salt is obtained in beautiful ruby-red crystals, termed, from their color, *red prussiate of potash*. This substance is well adapted for many operations in dyeing, but it is too expensive for general use. It yields the following colors with the salts of the different metals undernamed:—

Bismuth,	Pale yellow.
Cadmium,	Yellow.
Cobalt,	Dark-brown red.
Copper,	Yellowish-green.
Protosalt of iron,	Deep-blue.
Persalts of iron,	No precipitate.
Manganese,	Brown.
Mercury,	Red-brown.
Nickel,	Yellow-green.
Tin,	White.
Zinc,	Orange-yellow.

It will be observed by this table, that the salts of iron which yield a blue with yellow prussiate of potash, give no color with the red prussiate; and the protosalt of iron, which gives only a gray with yellow prussiate, yields a deep blue with red prussiate.

Yellow prussiate of potash is also used for dyeing *shades of light brown* with salts of copper. It is also much used for dyeing *dark mazarines* and other shades of blue upon woolen, cotton, and velvet. By a very ingenious process of fixing a deep blue without any previous preparation of iron, it is principally used in calico-printing, and is effected by *a mixture of yellow prussiate, sulphuric acid*, and some *of the vegetable acids*, and *salts of tin*.

The process for obtaining this beautiful color upon velvets, has been but recently introduced, and is as yet not much known. It seems to depend upon the fixing of what is known as *Everett's salt* upon the goods. When an acid is added to prussiate of potash, the greater portion of the potassium is taken up by the acid, but the iron and a part of the cyanogen remain, which unite and form a compound of two of cyanide of iron and one of cyanide of potassium. This salt is yellow, but rapidly absorbs oxygen, becomes green, and then passes into a deep blue color.

SAFFLOWER AND PRUSSIAN BLUE.—The most beautiful *lilacs*, *puces*, and *lavenders*,* are obtained by safflower and Prussian blue; but it is one of the most difficult colors to produce of equal shade. The goods are generally dyed a blue first by nitrate of iron and prussiate of potash (see last article), and then put through the safflower solution, previously made acid; but the rapidity with which the cloth takes up the red, renders it almost impossible to get a perfectly even dye. Another method is to dye the cloth in the first instance pink, and then to dye it blue. This method gives a more equal dye, but the mode is liable to serious ob-

* A very good lavender may be obtained in the following manner:—Bottom with indigo, and then pass through a bath of barwood spirits, as described in chapter I. of this Part, article *Barwood Red Spirits*. The goods are now to be passed through a bath of logwood liquor. Redden with alum or the red bath.

jections: the nitrate of iron used has always free acid which materially destroys the red of the safflower, and even although the nitrate of iron were neutral, this evil is not overcome, and the resulting color has not the same beauty as that blued first; and, besides this, a portion of the safflower is dissolved by the nitrate of iron, thereby creating considerable loss. These difficulties may be almost wholly avoided by using instead of the nitrate the *persulphate* of iron, which may be prepared in the following manner:—

Dissolve some protosulphate of iron (copperas) in water, and bring it to the boiling point; then add nitric acid by degrees, till all effervescence ceases, or no red fumes are given off. By this means the iron is peroxidized.

This operation must not be performed in any metallic vessel on account of the property which persalt has of dissolving all metals. To this peroxidized salt-solution, *ammonia* is added *as long as any precipitate falls;* this is now well washed with hot water, filling up the vessel, allowing the precipitate to settle, throwing off the clear liquor, filling again with hot water, and so on; three or four times will commonly be sufficient. A little ammonia remaining does no harm. To the precipitate is added a little sulphuric acid, *which dissolves the peroxide of iron*, and any slight quantity of ammonia which yet remains; by a little evaporation the whole will crystalize in *lavender colored* crystals. If crystalization be attained, the crystals may be used, dissolved in water; if not, a little of the solution may be taken, and the operation of dyeing conducted as with nitrate of iron. A little free acid in this salt does no harm.—(See *Calico Printing*, Part VI.)

CHAPTER VI.

OF ORANGE.

PROCESSES OF DYEING ORANGE ON COTTON.

Preliminary observations—Splendid Processes of Dyeing Orange on Cotton—Precautions to be observed—Anotta, Improved method of Dyeing with—Remarks on this Coloring Substance—Salmon and Nankeen Colors.

Preliminary observations.—Orange color is the most powerful of the secondaries, and is a compound of yellow and red, in proportions of three of yellow to five of red. Between these two colors it appears in the prismatic spectrum, rainbow, and other natural phenomena. They are, therefore, its melodizing colors, and its contrasting color is the primary blue. Orange is the extreme point of warmth in coloring, as blue is of coldness; they, therefore, form a perfect contrast in this respect, as they do in their numerical proportional power, being eight to eight. The mixture of red with yellow adds power to the native warmth of the red; orange is, therefore, conjointly in regard to light and color, most powerful in its effect upon the eye. From its combination with green arises the hue citrine, and with purple that of russet.

Orange, like the other two secondaries, has great variety of tone, according to the predominance of either of its component parts. As it passes towards yellow, by a predominance of that color in its mixture, pure blue no longer forms its proper contrast, but tones of bluish purple advancing towards perfect purple, as the orange color retires into yellow. On the other hand, when the orange color advances towards a reddish tone, bluish-green becomes its proper contrasting color—the blue approaching the perfect secondary, as the orange approaches the primary.

Although orange is perhaps the most powerful of all colors,

yet it possesses a mellowness and richness which renders it one of the most effective in all general arrangements. It should, however, next to yellow, be employed with a very sparing hand; for it is, as well as that primary and red, offensive to the eye when viewed alone, and unresolved by a proper proportion of its contrasting and melodizing hues. The various beautiful tints produced by the dilution of orange, are the most useful in heightening all ornamental coloring, amongst which that termed gold color is pre-eminent.

Suppose orange to be the archeus or key-note adopted for an arrangement of colors, either in the decoration of an apartment, or in the design of a carpet, or other piece of manufacture, the blue should be subordinate, either in intensity or quantity; and this subordination in intensity should be in shade rather than tint, or by neutralizing the blue by the admixture of a small portion of orange color.

In the medial colors employed in an arrangement of this character, the deep rich tones of russet, citron, and brown, should predominate, relieved occasionally by the deepest shades of indigo. Black and white are both out of tone in such an arrangement, especially the latter.

Pure orange, from its great power, is not often employed in decoration, yet many of its hues are the best adapted for window curtains, chair seats, and other furniture, where gorgeousness and splendor are desirable. The gold and giraffe hues so employed, along with the cool emerald tint of green on the walls, produce, when properly harmonized by their accompaniments, one of the most pleasing effects in ordinary decoration. In this case, however, the green is the ruling color, and such an arrangement will therefore admit of all such hues and tints being introduced as harmonize with that color.

PROCESSES OF DYEING ORANGE.—Chrome orange is obtained by fixing upon the goods the sub-chromate of lead (described in chapter IV. of this Part). This is effected in the following manner:—

The goods are first dyed a deep yellow, and then passed through a strong hot alkaline solution, which combines with a portion of the chromic acid, and leaves

the sub-chromate of lead upon the cloth. But the method for dyeing the yellow for this purpose, is more consistent than the ordinary process for producing yellow.

We have already* alluded to the preparation of *sub* or *basic* salts of lead, and to the proper proportions and the method of obtaining them, with their use in dyeing in preference to the ordinary salt for heavy colors. We will now give the method of preparing them in the dye-house, with the best method of dyeing orange, and which is as follows:—

To dye a hundred pounds of cotton, 30lbs. of brown sugar of lead, and 17lbs. of litharge, are put into a boiler with about 12 gallons of water, and boiled together for an hour or so, until the litharge is dissolved; then a quantity of lime, from one to two pounds, is added, any sediment is allowed to settle, and the clear fluid drawn off and put into a tub for the purpose; 12lbs. bichromate of potash is dissolved in another tub. Two other tubs, capable of allowing 10 lbs of yarn to be wrought in them with freedom, are filled, one with water, to which a little solution of lead is added, and the other with lime-water; 10 lbs. of the yarn (a bundle) is now wrought for some time through the tub containing the lead, wrung out and put through the lime-water, a little more lead is added, another bundle is passed through the same tub, renewing the lime-water each time. The whole are operated upon two or three times, according to the depth of orange wanted. The bundles are next put through a tub of water, to which is added some of the solution of bichromate of potash,† and then through the lead solution. The solution of lead is generally renewed at this stage of the operation. After being all put through, they are again passed through the chrome. A saturated solution of newly dissolved lime is brought to the boiling point, the yarn is now wrought in this, either by drawing some off in tubs, or by the most convenient method that circumstances will allow, until the color is changed to a deep orange or scarlet. It is then taken out, passed through another tub filled with boiling hot water, to which is added a small quantity of a solution of soap, soda, and oil, wrung out and dried at a high temperature.

The raising of the orange, as the hot liming is termed, is the most trying operation. If the lead has not been properly prepared, or if there be any mismanagement in the operation of fixing it upon the fibre, the hot lime will take all the color off, leaving but a red salmon shade, or it may come

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* See chapter I. of this Part, and *Appendix*, article *Acetate of Lead*.

† Bichromate of potash has been very extensively used of late as a mordant for a variety of colors upon *woolen* goods, and *is entirely superseding several of the old processes of dyeing many of the ordinary shades*, which were very tedious in manipulation.

off in parts. Several causes operate to produce these results, which we have not space to detail here at present.* Oranges being once done wrong, they are very difficult to recover.

ORANGE WITH ANOTTA.—Anotta contains two coloring matters; one yellow, the other red. They are barely soluble in water, but easily in alkalies, and are by this means prepared for dyeing. The alkali used is carbonate of soda or potash, but common soft soap does equally well, and for certain light shades upon silk and cotton, is superior. A quantity of anotta is prepared at a time, and kept as a sort of stock liquor; but the practice is bad as it soon becomes stale, and loses a great portion of its dyeing properties; it should be used when newly prepared. It is prepared as follows:—

Into a boiler capable of containing from ten to twelve gallons of water, is put 10 lbs. weight of anotta, 2 lbs. of carbonate of soda, and 2 lbs. of soft soap, the whole boiled together until the anotta is all dissolved.

Cloth put into this solution will be dyed *a dark orange*, and every tint of shade from an orange to a light cream color may be dyed by this solution, by merely using it less or more diluted according to the shade required; the cloth requires no previous preparation; but for light shades, the color is brightened by having a little soap dissolved in the water where they are dyed: in this case the goods are merely wrought in the liquor for a little, wrung out and dried. The addition of acids turns the colors dyed by anotta to a yellowish red, so that by passing a piece of cloth dyed orange with anotta, through a little acid water, it is turned into a scarlet, and so on down to a light salmon color.

It is to be regretted, that all the colors dyed by anotta are exceedingly *fugitive;* and although neither acids nor alkalies can completely remove the colors given by this substance from the cloth, yet they are constantly changing and fading by exposure to the air and light, and consequently anotta is very little used to produce a dye by itself in a cotton dyehouse, but as an auxiliary, or what dyers term, giving a bot-

* See chapter VII., next chapter, *Processes of Dyeing Green on Cotton.*

tom to colors; as in the case of scarlet, *the cloth is first dyed orange by anotta*, and *a crimson dyed above it by safflower*, which together produces *a beautiful scarlet.*

It is used in considerable quantity for dyeing silk and wool the various shades of *orange*, *salmon*, *nankeen*, &c.; the objection, just referred to, respecting its use for cotton is not so applicable to silk and woolen, probably owing to the superior affinity that animal substances have for dyeing agents, when compared to vegetable substances.

Anotta is eminently fitted for dyeing the shades alluded to above upon goods of mixed quality, such as Canton crape, Batiste, and all such cloth composed of cotton and silk, cotton and wool, silk and wool,—a kind of goods which require a considerable experience in the arts, to be able to produce an equality of every color upon the different materials.*—(See chapter III., Part I.; see also chapter IV., of this Part, and chapter III. of Part V.)

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* The best method of dyeing both silk and cotton with anotta or safflower is by wincing the piece in an imperfectly neutralized alkaline infusion of the dye-stuff, which contains the coloring matter in a state of feeble suspension, readily precipitated on a solid body presenting a finely divided surface, such as cloth. The partial neutralization of the alkali in this process is effected by a very weak acid, or an acidulous salt, such as bitartrate of potash (cream of tartar).—*Parnell.*

CHAPTER VII.

OF GREEN.

PROCESSES OF DYEING GREEN ON COTTON.

Preliminary Observations—Processes of Dyeing Green on Cotton—Precautions to be observed—Preparations of Chemic for Cotton Dyeing—Remarks on this Process—Mistaken Notions of Dyers generally on Dyeing Greens, and the Preparation of Chemic for Cotton Dyeing—Green on Cotton with Fustic as the Yellowing Substance—Drabs, Fawns, Olives, and Iron Browns.

Preliminary observations.—Green is the medial color of the secondaries, being a compound of yellow and blue, in the proportions of three of yellow to eight of blue. Its melodizing tones being these two primaries, and its contrasting color red. As red is the most decided and powerful of the primaries, so green is the most neutral and soft of the secondaries, and the most pleasing and agreeable of all decided colors to the eye. It is unlike the other two secondaries in this respect—that, in its approximation to either of its component parts, it produces no other distinct denomination of color; all its varieties of tone retaining the same name. From the union of green with orange arises the lightest of the hues, citrine; and from that with purple the deepest, olive color—to which it is particularly allied.

Green is nature's favorite color, prevailing to a far greater extent in the vegetable kingdom than any other. By a beneficent exercise of the Divine wisdom, it is exhibited in its greatest intensity and depth when the sun's rays are most powerful, thereby counteracting the intensity of their reflection, and refreshing the eye by its soft and soothing influence. Green, however, seldom appears in vegetation in its primitive purity—hence the beautiful accordance between the

green of the landscape and the blue of the sky, assisted by the intervention of the warm and neutral gray which prevails immediately in the distance in the one and the horizon of the other.

Of all decided colors, green may be used with most freedom in manufactures. In *carpets*, especially, it should almost always preponderate. They receive the rays of light more directly during the day than any other part of the furniture or decoration; and this color is not only in that light most pleasing, but also relieves and harmonizes others more generally in its various hues than any other color. Its bright and vivid hues and tints are easily neutralized, and seldom produce crudity or harshness of effect in any arrangement. Rich and deep tones of green, especially when neutralized towards a tertiary hue, harmonize with and give value to all denominations of warm colors. Its cooler hues and shades should, however, be used with more caution; for they are apt to appear blackish and heavy. The blue, no doubt, predominates in them to the same extent that it does in the hues of purple called indigo, yet they have not the same clearness.

The effect of green is much deteriorated in artificial light, from the cause already explained in the treating of yellow.

PROCESSES OF DYEING GREEN.—Chrome greens are dyed in the same manner as the yellow,* *the goods being previously dyed blue by means of the blue vat.* For dyeing green, nitrate of lead is never used, as anything that tends to redden the hue is carefully avoided, so that the goods are not allowed to stand for any time out of the solution of the bichromate, yet with all the care that is used there is much difficulty in avoiding brown blotches and light spots. This has been alluded to in the last chapter (VI.); but we may add here, that if *the lead were reduced to the state of an oxide upon the goods previous to being put into the bichromate of potash, and no acid added to the chrome solution*, there would be neither brown nor light spots upon

* Described in chapter IV. of this Part.

the goods, and with ordinary care the color would be perfectly uniform.*

The method practised by the majority of English and Scotch dyers for obtaining chrome-green on cotton is as follows:—

1. 50 lbs. of yarn. Dye the yarn blue in the cold indigo vat according to the depth of shade required. Clear in warm water.

2. Boil 20 lbs. sugar of lead till dissolved—put in 5 lbs. litharge, and boil 40 minutes—draw the fire, and give 1½ lbs. slacked lime—stir up and then allow to settle.

3. Make up a tub with cold water—Take the clear of No. 2. just described, and add of the liquor till it stands 2½ by "Twaddell's hydrometer,"—enter the first ten lbs. of yarn, give five turns. Wring out, and put it in the frame. Go on with the next bundle of yarn in the same way—keeping the tub always at 2½, as above directed.

4. The goods are now passed through the tub (3) as before, making the last bundle go first, and keeping the tub at the same strength.

5. Make up a tub with cold water with half a pound of chrome to every 10 lbs. of yarn—stir up and enter—give five turns. Wring out, wash off with a little clear lead, and dry.

PREPARATION OF CHEMIC.—The method of preparing chemic for dyeing green upon *light cotton goods*, is, perhaps, the nicest of all its preparations.† The acid solution of indigo is put into about twenty gallons of boiling water to the pound of indigo. Exact measurement is not material. In mixing this solution with the hot water, it is known whether the indigo and the acid are in complete combination; if they are not, the acid sputters and boils in the same manner as vitriol does when poured into hot water; if they are combined, it goes down into the hot water as calm as water would do poured into oil. To this mixture, finely pounded chalk or whitening, is added by degrees, until the acid is exactly neutralized. This is the most particular part of the operation. Although a pound of whitening to the pound of acid used, comes very near the proportion, yet there are so many circumstances which may alter measured proportions that they cannot be relied upon. Were the acid

* See *Appendix*, article *Acetate of Lead*.

† See chapter V. of this Part, article *Preparation of Chemic*.

property to prevail in the least, it would destroy the yellow upon the cloth to be dyed green; and were the alkaline matter predominant, it would brown the yellow, and the green would assume a blackish-olive shade. Thus the beauty of the colors depends upon the dyer being careful just to stop at the *turning* point. The only method employed by dyers for determining the point of neutrality is the taste; and this, from many circumstances which we need not enumerate, is liable to error; and when the dyer is deceived, the results are very annoying, and also expensive. Were very delicately prepared blue and red litmus papers used, the results would be much more certain. However, the reader may be astonished when we inform him, *that scarcely one instance out of ten goes wrong from this cause.* Some dyers use carbonated alkalies, such as soda and potash, to neutralize their acid; and no doubt when any of these are used, the sediment at the bottom is much less; but we have always thought this owing to the salts formed by these alkalies being dissolved in the blue solution, and have invariably found that the green color was not so good, especially if *bark* was the yellowing substance. The process of dyeing greens by this sort of prepared chemic is as follows:—

The goods, after being well boiled and washed, are put through a dilute solution of pyroligneous acid of sp. gr. 1·035, that is, 7 of Twaddell, and washed from this through hot water; they are then wrought through a decoction of *quercitron bark.** When sufficiently yellow for the shade of green required, they are wrought through a quantity of chemic mixed with cold water; wrung from this and dried.

GREEN WITH FUSTIC, BLUE VAT, &c.—A good deal of cotton is dyed green by fustic, especially yarn. The yarn is first dyed blue by the blue vat, and then passed through a little pyrolignite of alumina; it is next wrought in a hot decoction of fustic, which communicates a beautiful rich shade of green.

Fustic is also used along with some kinds of Brazil-wood to give a richness to red colors; and also as an ingredient in

* If fustic is the yellowing substance used, alum is a better mordant.—See chapter I. of this Part.

drabs, *fawns*, *olives*, and what is termed *iron browns*. The method of dyeing dark fawns is as follows :—

The goods are first dyed a good deep orange, by passing them through a solution of anotta, and washed from this; a tub is then prepared with a mixture of sumac, fustic, and a little logwood; the goods are wrought in this for some time; after this, a little copperas is added; the goods are again immersed, and wrought for six or seven minutes; they are then washed and put into another tub containing fustic, with a very little logwood and Brazil-wood; after working a little this is *raised* with alum, then washed and dried. The relative quantity of the ingredients used must of course be regulated according to the depth and particular hue wanted.

CHAPTER VIII.

OF PURPLE.

PROCESSES OF DYEING PURPLE ON COTTON.

Preliminary observations—Processes of Dyeing Purple—Mercer's Patent Purple Liquor—King of Purples, De Normandy's Patent—Violets—Buffs, &c.

Preliminary observations.—Purple arises from the union of red and blue, in the proportions of five of red to eight of blue, and forms the proper contrast to pure yellow. The two colors of which it is compounded are its melodizing tones. Although red is one of its component parts, purple is retiring in its effect, being the darkest of the secondary colors. In combination with green it produces that soft and useful hue, *olive;* and with orange the most powerful of this class, *russet.*

Purple, like the other two compounds, has various tones according to the predominance of one or the other of its elements; but these are bounded in its approach to red by crimson, and towards blue by indigo. Its tints have also names peculiar to themselves, such as *lilac, peach-blossom, French white,* &c.

These primary and secondary colors form the full scale of the chromatist, and have all proper names except orange, which is so called from its resemblance to the color of that fruit. They continually occur in various degrees of intensity in all chromatic spectra produced by the refraction of light, and are therefore properly called colors.

Purple may be used in large quantities in any general arrangement, especially when of a cool tone. In the richest patterns of *carpets,* shawls, and such like pieces of manufacture, its deepest hues are invaluable. Its power of contrast

to all the warm tones of yellow gives them additional warmth and brilliancy; while its natural clearness prevents it from ever appearing dusky or heavy.

PROCESSES OF DYEING PURPLE.—The finest madder purples may be obtained by a mixture of Mercer's "Patent Purple Liquor," or assistant mordant, and which has been described in chapter I., of this Part, article *Mercer's Assistant Mordant.* At present we shall merely notice a mode of obtaining purple liquor, either for dyeing or writing, recently patented by M. De Normandy, of Paris, and by which, he says, he obtains a splendid purple color: he calls it the "King of Purples." This color he obtains from logwood (Hœmatoxylon Campechiacum). The following proportions must be observed:—

To 12 lbs. of logwood, add as many gallons of boiling water; pour the solution through a funnel, with a strainer made of coarse flannel, upon 1 lb. of hydrate or acetate of deutoxide of copper, finely pulverized, (at the bottom of the funnel a piece of sponge is placed;) then add, immediately, 14 lbs. of sulphate of alumine and potash, and for every 340 gallons of liquid, add 80 lbs. of gum arabic or gum Senegal.—Let these remain for three or four days, and a beautiful purple color will be produced.

VIOLETS.—Chaptal obtained a tolerably agreeable violet, by dyeing red cottons blue, in the preparation of which he diminished the quantities of oils and galls, and, on the other hand, increased that of alum, as well as the brightening process. He attempted to give cotton a violet, which would yield neither in durability or lustre to the red made in his dye-houses; and after having been led by his researches to a great variety of processes, which afforded with more or less facility the color sought for, he preferred the following:—

1. The mordant for 200 lbs. of cotton, is prepared with 50 lbs. of sulphate of iron (copperas), and 12 lbs. of acetate of lead. The clear liquid is separated from the deposit that is formed; and the cotton is passed through it with care, after receiving three oils,* as hot as possible.

2. On taking the goods out of the bath, they are wrung and handled over: and when they have assumed, on cooling, a buff shade, they are to be well washed, wrung, and dried, with accurate stretching.

3. The weight of the goods, of madder, is employed for dyeing them: as soon

* The same as for Turkey-red, as described in chapter III. of this Part.

as the bath becomes tepid the cotton is plunged in, with gradual increase of the heat, but without boiling. When the goods have become bluish-black, they are taken out and washed.

4. They are now brightened in soap, during 15 or 20 minutes.*

BUFFS.†—Tinned iron plates, (refuse cuttings of a tinman's shop) dissolved in aqua regia, three parts nitric and one muriatic acid. Then raise the color in lime water, about half a pint of lime to the gallon of liquor. Repeat the process for a full color. The color is permanent.

It is utterly impossible to give directions for all the various shades of these colors, as slight variations in the proportions of the ingredients may be easily made to suit each tint of color.

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* For fast colors, says Mr. Cooper, the better plan is to give a ground of blue in the blue vat, and then dye with madder and brazil. By soaking the goods, in the first instance, in the acetate of alumina, of a strength according to the shade required.—(See *Mordants*, chapter I. of this Part, article *Alum*.)

† See chapter I. of this Part, article *Iron*.

CHAPTER VII.

OF GREEN.

PROCESSES OF DYEING GREEN ON COTTON.

Preliminary Observations—Processes of Dyeing Green on Cotton—Precautions to be observed—Preparations of Chemic for Cotton Dyeing—Remarks on this Process—Mistaken Notions of Dyers generally on Dyeing Greens, and the Preparation of Chemic for Cotton Dyeing—Green on Cotton with Fustic as the Yellowing Substance—Drabs, Fawns, Olives, and Iron Browns.

Preliminary observations.—Green is the medial color of the secondaries, being a compound of yellow and blue, in the proportions of three of yellow to eight of blue. Its melodizing tones being these two primaries, and its contrasting color red. As red is the most decided and powerful of the primaries, so green is the most neutral and soft of the secondaries, and the most pleasing and agreeable of all decided colors to the eye. It is unlike the other two secondaries in this respect—that, in its approximation to either of its component parts, it produces no other distinct denomination of color; all its varieties of tone retaining the same name. From the union of green with orange arises the lightest of the hues, citrine; and from that with purple the deepest, olive color—to which it is particularly allied.

Green is nature's favorite color, prevailing to a far greater extent in the vegetable kingdom than any other. By a beneficent exercise of the Divine wisdom, it is exhibited in its greatest intensity and depth when the sun's rays are most powerful, thereby counteracting the intensity of their reflection, and refreshing the eye by its soft and soothing influence. Green, however, seldom appears in vegetation in its primitive purity—hence the beautiful accordance between the

mellowed down by some warm color. More latitude may be taken with black in silk manufactures, as it can be produced on that material in the greatest clearness and depth.

PROCESSES OF DYEING BLACK.—In order that the reader may obtain a thorough *practical* knowledge of the *best* modes of dyeing this (as well as every other) color, he must study *attentively* the uses and chemical characters of the various dye-stuffs, Animal, Vegetable, and Mineral, as given in this work. We will, therefore, commence by referring him to the article on *Logwood*, chapter III., Part I., and to chapter I. of this Part, article *Iron.*

Of the thousands of recipes prescribed in books, for procuring a permanent black on cotton goods, not one has ever perfectly answered the purpose. There is but one method known of procuring a durable as well as beautiful black on *cotton*, and for the discovery of which we are indebted to Mr. Kœchlin, of Alsace. The following is the process:—

1. The goods are allowed to steep in a decoction of sumac for twelve hours; after which they are wrought through lime-water, which gives them a beautiful blueish-green color, becoming very dark with a short time's exposure to the air. If allowed to stand for half an hour, the green color passes off, and the goods assume a greenish-dun shade.

2. When the goods are at the darkest shade of green, they are put through a solution of copperas: after working some time in this, and allowing them to stand exposed to the air, they become a black. But if dried from this, it is only slate or dark-gray.

3. The goods are again put through lime-water, which renders them brown, and then wrought through a decoction of logwood till the color of the wood has nearly disappeared.

4. A little copperas is now added, which throws off the reddish hues of the wood, giving them a blue shade. This is termed *raising* the color.

5. The goods are washed from this in cold water, and dried in the shade.

6. When a deep blue-black is wanted, the goods are dyed blue previous to steeping in the sumac.

This method of dyeing black, on cotton, is rapidly superseding the old processes as practiced in England, Ireland, Scotland, and France.

We formerly mentioned (in chapter I. of this Part) *tin as a mordant for logwood*, the goods being put through the solution, and afterwards well washed. Was this salt of tin remaining soluble when the goods were washed, the mordant

would be dissolved from the cloth; but the chloride of tin in the cloth is decomposed during the operation of washing, and there remains fixed in the fibres, the insoluble compound of tin, constituting a mordant which combines easily with the logwood.* Probably the cloth itself acts a part in assisting this decomposition, which would account for its being dyed permanently by immersions into a soluble compound of tin and logwood, as noticed in reference to plumb tubs in the same chapter, but the various compositions of tin and logwood have *not yet* been studied chemically. There are a number of other vegetables, besides galls and sumac, which contain tannin† in great abundance, and which have all been described in Part I. chapter III., and chapter II. Part III. The various combinations of tannin with the metallic oxides, especially *tin*, are noticed in chapter I. of this Part.

CATECHUE BROWN.—To dye this color, proceed as follows:—

The catechue is boiled in water till dissolved. Let the boiling cease, then add a little nitrate of copper; say that a cent is dissolved in two gills of aquafortis, this will do 10 lbs of catechue. The whole is well mixed, and the cotton immersed and allowed to remain in it till the solution becomes cold, generally over night; it is then to be taken out and well wrung, and wrought for nearly twenty minutes in a solution of bichromate of potash (chrome) at nearly a boiling heat, it is then washed and finished through a solution of soap, sufficiently strong to stand a lather after the goods come out.

* The mordant much employed (for cotton goods) in Germany for this dye (black); with logwood, galls, sumac, &c., is *Iron-Alum*, so called on account of its having the crystaline form of alum, though it contains no alumina. It is prepared by dissolving 78 pounds of red oxide of iron in 117 pounds of sulphuric acid, diluting this compound with water, adding to the mixture 87 pounds of sulphate of potash, evaporating the solution to the crystalizing point. This potash-sulphate of iron has a fine amethyst color when recently prepared; and though it gets coated in the air with a yellowish crust, it is none the worse on this account. As a mordant, a solution of this salt, in from six to sixty parts of water, serves to communicate and fix a great variety of uniform ground colors, from light gray to brown, blue, or jet black, with quercitron, galls, logwood, sumac, &c., separate or combined. The above solution may be usefully modified by adding to every 10 pounds of the *iron-alum*, dissolved in eight gallons (80 pounds) of warm water, 10 pounds of acetate (sugar) of lead, and leaving the mixture, after careful stirring, to settle. Sulphate of lead falls, and the oxide of iron remains combined with the acetic acid and the potash. After passing through the above mordant, the goods should be quickly dried.—*Ure.*

† See *Tannin* and *Gallic Acid*, chapter II. of this Part.

This produces a very rich permanent brown, *and is already superseding the use of madder for the same color*, being nearly equally permanent and more easily obtained. The shade is varied according to the proportion of the ingredients used, so that *a rich vanterine* or *a dark chocolate* may be obtained with equal facility.

BROWNS WITH QUERCITRON BARK, &c.—The modes of dyeing brown with quercitron bark, and the use of yellow spirits (see chapter I. of this Part, article *Yellow Spirits*), is not very suitable for cloth. The best mode is the following:—

1. Impregnate the cloth with pyrolignite of alumina, and dye it yellow in the same manner as given for dyeing greens.*

2. A bath is now prepared with logwood and Brazil-wood, about one part of the former to two of the latter; the goods are then wrought in this mixture for ten minutes, when a little alum is added, and they are wrought ten minutes longer; they are then washed from this and dried. If the ingredients be well proportioned, this method gives beautiful shades of brown.

"Brown of different shades is imparted to cotton and linen, by impregnating them with a mixed mordant of acetates of alumina and iron, and then dyeing them, either with madder alone, or with madder and fustic. When the aluminous mordant predominates, the madder gives an amaranth tint.† For horse-chestnut brown, the cotton must be galled, plunged into a black bath, then into a bath of sulphate of copper, next dyed in a decoction of fustic, wrung out, passed through a strong madder bath, then through the sulphate of copper solution, and finished with a soap boil.

"A superior brown is produced by like means upon cotton goods, which have undergone the oiling process of the Turkey red dye. Such stuffs must be galled, mordanted with alum, sulphate of iron, and acetate of lead (equal to ⅓ of the alum); after washing and drying, dye in a madder

* See chapter VII. of this Part.

† *Amaranth.*—M. Vitalis gives us the following receipt for obtaining this color:—1. The cotton is strongly galled, dried, and washed. 2. It is passed through black dye, till it has taken a strong gray shade. 3. It receives a bath of lime-water. 4. Mordant of tin. 5. Dyeing in the Brazil-wood bath. 6. The two last operations are repeated.

bath, and cleared with a soap boil. The tint of brown varies with the proportion of alum and sulphate of iron.

"We perceive from these examples, in how many ways the browning of dyes may be modified, upon what principles they are founded, and how we have it in our power to turn the shade more or less towards red, black, yellow, blue, &c."*

CINNAMON.—Different shades of cinnamon may be obtained, when cottons first dyed with madder get an olive cast with iron liquor in a fustic bath.

These cinnamon and mordoré shades are also produced by dyeing them first in a bath of weld and verdigris, passing them through a solution of sulphate of iron, (copperas) wringing and drying; next through a bath containing 1 pound of galls for every 10 pounds of goods, again drying; next aluming, and maddering. They must be brightened by a boil in soap water.

Cinnamon color, on either silk or cotton, may also be obtained in the following manner:—

"Run the goods through a solution of sulphate of copper (blue vitriol); then pass through lime-water, which will give a handsome sky-blue of considerable permanency. Now run the goods through a solution of prussiate of potash. This gives them a beautiful brown.

* *Ure.*

PART FOURTH.

DYEING PROCESSES CONTINUED.

CHAPTER I.

OF RED.

PROCESSES OF DYEING SCARLET ON WOOL.

Observations on Colors, Simple and Compound—Proper names—Mordants of the different Authors for Dyeing Scarlet—Dyeing Processes, English, French, German, and Italian—General Remarks on these Processes—Lac-Scarlet—Crimson—Rose Colors—Brazil-wood Scarlet—Madder Red, &c.

THE only proper names amongst colors are red,* yellow, blue, green, purple, citrine, russet, and brown; with white, gray, and black, for light, shade, and darkness. Red has, no doubt, two other varieties to which proper names have been given—namely, crimson and scarlet; the first being the admixture of red with a small proportion of blue, and the second being the same with a small proportion of yellow, as shall be pointed out in the sequel. But they approach in appearance so near the primary color, that their names are often used as a general term for red. The term crimson is derived from the Italian *crimosino*, and that of scarlet from the French *escarlate*.

White and black are representatives of the principles of light and darkness; and yellow, red, and blue, the primary

* See chapter III. Part III. article *Preliminary Observations*.

elements of color, out of which, by commixture and union amongst themselves, every conceivable variety of color and hue arises.

The nature and qualities of these elements of chromatic beauty must be well understood before a correct idea can be formed of, or proper names given to, their various combinations. White and black are not colors themselves, but are, as the representatives of light and darkness, simply the modifiers of colors, in reducing them, and the hues arising from them, by their attenuating and neutralizing effects, to tints and shades respectively.

The distinctive characteristic of a mixed color, must therefore depend upon the mode in which the primaries are combined in its composition; and, as these elements are but three in number, we can only have other two distinct kinds; namely, those in which two of them occur, called secondary colors, and those in which the whole three are combined, generally called tertiary colors. These last are, however, more properly called hues, because they are colors only by the predominance or subordination in their composition of one or other of the three primaries, above or below its natural power of neutralization, as shall afterwards be shown.

So much for the nature of the primary elements of color. Their powers shall now be considered.

That these elements can be produced in perfect purity, seems a physical impossibility; even in the solar spectrum they cannot be perfectly separated by any refracting power yet discovered, but are all to a certain extent mixed with those that lie next them in series. Notwithstanding this difficulty, their powers have been ascertained by various practical experiments, especially those performed by Field, to be, in regard to their capability of reflecting light in ratios, somewhat similar to those of the tonic, mediant, and dominant of the musical scale, or more properly to the harmonic ratios. It will therefore be found, that taking the purest powdered pigments that art can produce, and mixing them in the proportions—one yellow, two red, and three blue, of equal in-

tensity, a cool gray, such as produced by the mixture of white and black, will be the result.

It has long been maintained, that these three colors will produce white light. This, however, cannot be the case; for colors can only be excited, as in the solar spectrum, by the joint influence of light and darkness, and are an intermediate phenomenon between these two principles, the natural concurrence of which, in the absence of a refracting power, is, as in the mixture of pigments, a cool gray.

Before proceeding to describe the dyeing operations, we will give a list of mordants, commonly known as *composition* or *solution of tin*. The following are the methods most to be depended upon by the practical dyer for producing scarlet on woolen goods:—

MORDANT A, *by Berthollet.*—Dissolve in nitric acid of 30° B. one-eighth of its weight of sal ammoniac, then add, by degrees, one-eighth of its weight of tin, and dilute the solution, with one-fourth of its weight of water.

MORDANT B, *by Poerner.*—Mix one pound of nitric acid with one pound of water, and dissolve it in an ounce and a half of sal ammoniac. Stir well, and add, very slowly, two ounces of feathered tin.*

MORDANT C.—Pour into a glass globe with a long neck, three parts of pure nitric acid at 30° B.; and one part of muriatic acid at 17°; shake the globe gently, avoiding the corrosive vapors, and put a loose stopper in its mouth. Throw into this nitro-muriatic acid one-eighth of its weight of pure tin, in small particles at a time. When the solution is complete, and settled, decant it into bottles, and close them with ground stoppers. It should not be diluted before used.

MORDANT D, *by Dambourney.*—In two drachms Fr. (144 grs.) of pure muriatic acid, dissolve 18 grains of Malacca tin.

MORDANT E, *by Hellot.*—Take 8 ounces of nitric acid, diluted with as much water; dissolved in half an ounce of

* For the best method of feathering the tin, see chapter I. Part III., article, *Tin*.

sal ammoniac, and 2 drachms of nitre. In this dissolve one ounce of tin.

MORDANT F, *by Scheffer.*—Dissolve one part of tin in four of a nitro-muriatic acid, prepared with nitric acid diluted with its own weight of water, and one thirty-secondth of sal ammoniac.

MORDANT G, *by Dambourney.*—Take 1 drachm (72 grs.) of muriatic acid at 17°, one of nitric acid at 30°, and 18 grains of water, in which dissolve 18 grains of fine Malacca tin.

These solutions, so different in their preparation, must of course have different properties;* but one essential object is not obtained, namely, an uniform preparation of the composition; uniform as to the kind of acid, the strength of the acid, and the proportion of tin and of other ingredients if any such are used. For this purpose it is absolutely necessary to have pure nitric acid, and of a given strength. It should be also remarked that as the solution of tin is apt to become gelatinous, from the gradual oxidization of the tin, partly by nitric acid, and partly by imbibing oxygen from the atmosphere; it is best not to make too much of it at a time. The gelatinous effect, says Cooper, may be prevented by keeping the tin solution in a cool dark place, in a greenish glass bottle, well stopped with a glass stopper, with a little butter around the juncture to exclude the air.

Long experience, says Berthollet, has shown, that if the solution be made so hastily and violently that the nitric acid is much decomposed, and many red vapors produced, the color is never so good on the cloth, as when the composition is made slowly, patiently, in a cool place, the tin put in by a grain or two at a time, and the composition used soon after it is made.

PROCESSES OF DYEING SCARLET.†—Scarlet is the

* See chapter I. Part III., article, *Tin.*

† The difference in the affinity of the coloring particles for wool, silk, and cotton, is sometimes so great, that they refuse to combine with one of these substances, whilst they combine very well with another; thus, cotton takes no color in the bath that dyes wool scarlet. Dufay got a piece of stuff made, the warp of

most beautiful and brilliant color among dyes. Taste fluctuates with regard to the shade in demand. Sometimes scarlet is sought for of a perfect and deeper red; more frequently inclining more or less to the color of flame.

We cannot expect to obtain the desired shade from the precise doses prescribed in the processes, from variations in the quantity of the coloring particles contained in the different kinds of fine cochineal, and particularly from the solutions of tin that are used differing considerably from each other; but the just proportions of the ingredients to be employed may be readily determined by trials in the small way, so as to obtain the shade called for; and if the pieces which are dyed be above or below this shade, it is not difficult to find the suitable proportions.—(See chapter I., Part III., article, *Tin.*)

1. For 100 pounds of cloth, put into the water, when it is a little more than lukewarm, 6 pounds cream of tartar, and stir well. When the water becomes too hot for the hand, throw into it, with agitation, one pound of cochineal, in fine powder. An instant afterwards, pour in 5 pounds of the mordant A, stir the whole thoroughly. As soon as the bath begins to boil, introduce the cloth, and wince briskly for two or three rotations, and then more slowly. At the end of a two-hours' boil, the cloth must be taken out, and allowed to become perfectly cool, after which it should be well washed at the river, or winced in a current of pure water.

2. Now fill with water, and when it is at the boiling point, 5½ pounds of cochineal are thrown in, and mixed with care; when the crust, which forms upon the surface, opens of itself in several places, 14 pounds of the mordant A, must be added. Should the liquor be likely to boil over the edges of the bath, it must be refreshed with a little cold water. When the bath

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which was wool, and the weft cotton; he passed this stuff through the fulling-mill, to ensure the same preparation to the wool and cotton; but the wool took the scarlet dye, and the cotton remained almost white. It is this difference of affinity which makes it necessary to vary the preparations and the processes, according to the nature of the substance which we wish to dye of a particular color.—(See chapter I. Part III.)

has become uniform, the cloth is to be put in, taking care to wince it briskly for two or three turns; then to boil it for an hour, thrusting it under the liquor with a rod whenever it rises to the surface. It is lastly taken out, aired, washed at the river, and dried.

BERTHOLLET'S PROCESS (*with emendations*).—We shall now give Berthollet's method of dyeing scarlet. It is in vain to expect any required shade from the proportions indicated in the common recipes; for the cochineal varies in quality, and the composition is liable to great variety in strength, but by means of trials in the small way, the proportions necessary to any required color may be easily ascertained.* The first process is called the preparation, and is as follows:—

1. For one hundred and twelve pounds of woolen cloth, throw in six pounds and three quarters cream of tartar; stir well; then add half a pound of cochineal, and stir; then add five pounds and a half of a clear solution of tin (*Mordant A*), and again stir the liquor. When the whole is about to boil, enter the cloth, which must be turned on the wince with great rapidity three or four times, and afterwards more slowly. After thus turning it in the boiling liquor for two hours, heave out, air, and wash in the river.

2. Now empty the bath and fill with water. Heat the water, and when near the boiling point, throw in five pounds and a half of cochineal; it must be well stirred; when the stirring is left off and a crust appears on top of the liquor, which breaks spontaneously in several places, then pour in fifteen pounds and a quarter of the composition (*Mordant A*). If the liquor should then boil up to the edge of the cauldron, cool down with a little water.

3. The composition being well mixed, the cloth is turned into the bath, taking care to wince it rapidly for three or

* To employ cochineal in dyeing, it is absolutely necessary that it should be well ground and then sifted through a fine sieve; all the particles that do not pass the sieve, are found at the close of the operation undissolved, and without having materially parted with their coloring matter.

four turns; then more gently, but still not slowly, in the liquor during an hour, pushing it under the surface with a stick as often as it rises up; heave out, air, cool, wash, and dry.

Generally a bright flame color is in demand; in which case quercitron bark is added to the preparation.* When this is the case, it can be discovered by cutting the cloth, the inside of which will show marks of the yellow dye, for in the common process the cochineal does not penetrate quite through the cloth.

SCHEFFER'S PROCESS (*with emendations*).—This author prescribes for the preparation bath, one part by weight of the composition to ten parts of cloth, with a tenth also of starch, and a tenth of tartar. He remarks that starch renders the color more uniform. He recommends to throw into the water when it boils, a quantity of cochineal equal to $\frac{1}{122}$th of the weight of the cloth, to stir it well, to boil the cloth in it for an hour, and then cool and rinse it. Then to boil it for half an hour in the finishing bath, with $\frac{1}{32}$d of starch, $\frac{1}{24}$th of solution of tin, $\frac{1}{32}$d of tartar, and $\frac{1}{12}$th of cochineal. The proportion of composition used by Scheffer, is much less than that used by Hellot, but his composition contains more tin than Hellot's.

POERNER'S PROCESS (*with emendations*).—Poerner describes three principal processes, according as the shades are to be more or less deep, or more or less orange. This consists in varying the quantities of composition and of tin, and of adding or omitting the tartar which contributes to the yellow or flame-colored hue of the scarlet. If the proportion of composition be too small, all the cochineal will not be taken up, and the water in the bath will be colored: if too large, it reacts on the color of the cochineal, dissolves it, and renders it liable to be washed out; hence the color comes out weak and faded. But if the cochineal be in proportion

* Several hundreds of experiments, says Dr. Bancroft, vol. I., p. 361, warrant my assertion that at least one-fourth of the cochineal generally employed in dyeing scarlet, may be saved by obtaining so much yellow as is necessary to compose this color, from quercitron bark.

to the tin, the color will be full and rich when they are used plentifully. The tartar gives the yellow tinge which with the crimson of the cochineal produces the flame color.

If the yellow tint should predominate too much, it is corrected by running the cloth, when dyed, through hot water; this effect is owing to some small proportion of calcerous salts contained in the water,* which if perfectly pure would not alter the color at all.

Poerner's three processes above alluded to will now be described.

PROCESS No. 1. 1. *Preparation bath.*—For every pound of cloth or wool, take 14 drachms of cream of tartar. When the bath is boiling, and the tartar all dissolved, pour in successively 14 drachms of solution of tin (*Mordant B*), and boil for a few minutes. Now introduce the cloth, and boil it for 2 hours; then heave out, let drain, and cool.

2. *Finishing bath.*—For every pound of woolen goods, take 2 drachms cream of tartar. When the bath begins to boil, add 1 ounce of cochineal; stir well, and let boil for a few minutes. Now pour in, by successive portions, 1 ounce of solution of tin (*Mordant B*), stirring continually, and then dye as quickly as possible. The color will be a beautiful scarlet.

PROCESS No. 2. 1. *Preparation bath.*—This bath is precisely the same as Process No. 1., and is always estimated for 1 pound of goods.

2. *Finishing bath.*—Take 1 ounce of cochineal, and 2 ounces of solution of tin without tartar.

PROCESS No. 3. 1. *Preparation bath.*—This bath is in all respects the same as the two already described above.

2. *Finishing bath.*—For a pound of cloth, take 2 drachms cream of tartar, one ounce of cochineal, one ounce of solution of tin, and two ounces of sea salt; finish as in Process No. 1. The salt helps the dye to penetrate into the cloth.

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* See chapter II. Part III., article *Purity of Water*. If the water is so pure as not to produce this effect of slightly crimsoning the color when too yellow, put about half an ounce or an ounce, at the most, of pearlash into a hundred gallons of water, which will operate as a corrective.—*Cooper*.

Tables showing the composition of the *preparation* and *finishing* baths, by Berthollet, Hellot, Scheffer, and Poërner, for 100 pounds of cloth or wool.

Preparation bath.

Names of the Authors.	Starch.		Cream of Tartar.		Cochineal.		Solution of Tin.		Common Salt.	
	lb.	*oz.*	*lb.*	*oz.*	*lb.*	*dr.*	*lb.*	*oz.*	*lb.*	*oz.*
Berthollet - -	0	0	6	0	8	0	5	0	0	0
Hellot - -	0	0	12	8	18	6	12	8	0	0
Scheffer - -	9	6	9	6	12	4	9	6	0	0
Poërner - -	0	0	10	15	0	0	10	15	0	0

Finishing bath.

Names of the Authors.	Starch.		Cream of Tartar.		Cochineal.		Solution of Tin.		Common Salt.	
	lb.	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*
Berthollet - -	0	0	0	0	5	8	14	0	0	0
Hellot - -	3	2	0	0	7	4	12	8	0	0
Scheffer - -	3	2	3	2	5	7½	4	11	0	0
Poërner -	0	0	1	8	6	4	6	4	0	0
	0	0	0	0	6	4	12	8	0	0
	0	0	1	8	6	4	6	4	12	8

M. Lenormand states that he has made experiments of verification upon all the formulæ of the preceding tables, and declares his conviction that the finest tint may be obtained by the *preparation* of Scheffer, and *finishing* (Process No. 3,) of Poerner.

LAC-SCARLET.—When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverized cakes, but as muriatic acid has been found to answer much better, it has entirely supplanted it. A good *solvent* for this dye-stuff may be prepared as follows, and which we shall call No. 1:—

No. 1.—Dissolve three pounds of tin in 60 pounds of muriatic acid, of specific gravity 1·19.

The proper *mordant* or composition for the cloth is made in the following manner, and which we shall call No. 2:—

No. 2.—Mix 27 pounds of muriatic acid of sp. grav. 1·17, with 1½ pounds of nitric acid of 1·19; put this mixture in a salt-glazed stone-bottle, and add to it, in small bits at a time, tin, till 4 pounds are dissolved.

This solution may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing, three quarters of a pint of the solvent No. 1 is to be poured

upon each pound of the pulverized lac-dye, and allowed to digest upon it for six hours. The cloth, before being subjected to the dye-bath, must be scoured with fuller's earth. To dye 100 pounds of cloth, proceed in the following order :—

1. Fill a tin boiler, of 300 gallons capacity, with water, and when at a temperature of 150° F., throw in a handful of bran, and half a pint of the solution of tin (No. 2). The froth which rises to the top as it approaches ebullition, must be skimmed off; and when the boiling commences throw in 10½ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1, and 3½ pounds of the solution of tin No. 2. An instant afterwards throw in 10½ pounds of tartar, and 4 pounds of ground sumac, both tied up in a linen bag. The sumac and tartar should remain in the boiling liquor for five minutes.

2. Draw the fire and add 20 gallons of cold water and 10½ pints of the solution of tin (No. 2); then enter the cloth and work briskly for ten minutes. Now rekindle the fire, and wince, slowly, bringing the liquor to a boil as quickly as possible: keeping it at that point for an hour. Wash well, and dry.

The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used, instead of tartar, and more sumac. Lac-dye may be substituted for cochineal in the orange-scarlets; but for delicate pink shades, it does not answer so well, as the lustre is apt to be impaired by the large quantity of acid necessary to dissolve the coloring matter of the lac.

CRIMSON.—The color produced by cochineal with alum* and tartar, is crimson. The wool must first be boiled in from two to four ounces of alum per pound of wool, according to

* *Alum* is the great mordant employed in wool dyeing. It is frequently dissolved in water, holding tartar equal to one fourth the weight of the alum in solution; by which addition its tendency to crystalize is diminished, and the resulting color is brightened. The alum and tartar combine with the goods without suffering any change, and are decomposed only by the action of the coloring matters in the dye bath. The alum operates solely in virtue of its sulphuric acid and earthy basis; the sulphate of potash present in that salt being rather injurious. Hence, if a sulphate of alumina free from iron could be readily obtained, it would prove a preferable mordant to alum. It is also probable, for the reasons above assigned, that soda alum, a salt much less apt to crystalize than potash or ammonia alum, would suit the dyer very well. In order to counteract the tendency of common alum to crystalize, and to promote its tendency to pass into a basic salt, one eighth part of its weight of potash is added to its solution, or the equivalent in chalk or soda.—*Ure.* See chapter I., Part III., article *Alum.*)

the fulness of color required, and half the quantity of tartar, then rinse the wool. Make ready for one hundred pounds of wool, a boiler that will hold fifty buckets of water; when the water boils, put in an ounce of sifted cochineal to the pound of wool, or more if the color be expected very deep. Let the cochineal boil ten minutes, stir, and enter the wool, which must be worked very quickly in the liquor for one hour and a half; and for a quarter of an hour, after all the cochineal seems exhausted. Then take out, wash and dry.—(See chapter III., Part V., article *Crimson.*)

ROSE COLORS.—Rose colors are dyed in the same way as crimson, except that only one half or one quarter of the cochineal is used, and from one ounce to half an ounce per pound of wool, of the tin composition. Some dyers dye their rose colors thus: they take of alum two ounces, cream of tartar one ounce, solution of tin one ounce, sifted cochineal a quarter of an ounce, to each pound of wool: boil the cochineal for a quarter of an hour; dissolve in a separate vessel the alum and tartar, to which when dissolved add the composition, stir this liquor well, and then add it to the cochineal liquor, and enter the goods, which must be worked in the mixture for an hour and a half. No rose color will require half an ounce of cochineal; one-third of an ounce, if good, is the fullest proportion.

BRAZIL-WOOD SCARLET.—According to Dingler and Kurrer, bright and fast scarlet reds may be obtained upon wool, by preparing a decoction of 50 pounds of Brazil-wood, in three successive boils, and setting the decoction aside for 3 or 4 weeks in a cool place; 100 pounds of the wool are then alumed in a bath of 22 pounds of alum and 11 pounds of tartar, and afterwards rinsed in cold water. In the meanwhile, a copper containing 30 pailsful is filled two-thirds, and heated to a temperature of 150° or 160° F. Three pailsful of the decoction are now poured in, and heated to the same point again, and 30 pounds of wool introduced, which does not take a scarlet, but rather a crimson tint. This being removed, 2 pailsful of the decoction are put in, and 30 pounds of wool, which becomes scarlet, but not so fine as at the third dip. If

the dyer strengthens the color a little at the first dip, a little more at the second, and adds at the third and fourth the quantity of decoction merely necessary, he will obtain a uniform scarlet tint. With 50 pounds of Pernambuco, 1000 pounds of wool may be dyed scarlet in this way, and with the deposits another 100 may be dyed of a tile color. Karkutsch says the dye may be improved by adding some ox-gall to the bath.

MADDER RED.—Wool would take with madder only a weak and perishable dye, were not the coloring particles fixed by a base, which combines them more intimately with the stuff, and which screens them in part from the destructive action of the air. For the accomplishment of this object, the stuff is, first of all, boiled with alum and tartar, for two or three hours; after which it is drained, slightly wrung, then enclosed in a bag, which is left in a cool place, and let alone for some days. Alumed wool takes, in the madder bath, a red color, which is not so bright, as a matter of course, as cochineal red, but it is a more permanent color; and being cheaper, is much used for household purposes. A mordant of alum and tartar is employed, at the rate of from *eight* to *sixteen* ounces for the pound of cloth. The bath is heated to a hand heat, and the goods are then dyed by the wince or reel. Vitalis prescribes as a mordant for this color, one-fourth of alum, and one-sixteenth of tartar; and for dyeing, one-third of madder, with the addition of a twenty-fourth of solution of tin diluted with its weight of water. He raises the temperature in the space of an hour to 200°, and afterwards boils for 3 or 4 minutes; a circumstance which it is believed, contributes to the fixation of the color. The bath, after dyeing, appears much loaded with yellow matter, because this has less affinity for the alum than the red.* We have, in chapter III, Part I., article *Madder*, treated extensively, and we trust to some purpose, of this subject, and to which the reader is referred.†

* Sometimes a little archil is added to the madder, to give the dye a pink tinge; but this is fugitive.

† See chapter III., Part III., article *Preliminary Observations.*

CHAPTER II.

OF YELLOW.

PROCESSES OF DYEING YELLOW ON WOOL.

Processes of Dyeing Yellow with Weld, Fustic, and Quercitron—Buff Yellow—Hendricks's Patent Process.

WITH WELD.—The method of dyeing yellow with weld, for a hundred pounds of cloth is as follows:—

100 lbs. of cloth.—1. Fill a boiler with weld, for a hundred pounds of cloth will not take less than an equal weight of weld, and for very deep yellows four times as much will be required.* Before the weld liquor boils, dye the cloths intended for light and bright yellows. It is best to wash them first at the river, to detach the grosser particles of alum that merely stick to the cloth. It is also a good plan to empty into another boiler as much of the dye-liquor as is necessary to dye the light yellows. When this is done the liquor, for the light yellows, need not boil over a few minutes before entering the goods to be dyed; first, however, throwing in some cold water to bring the liquor to a scald, just before entering the goods.

2. When the weld is taken out of the first boiler, boil it again in another. When exhausted, take out and use this second boiling, either to dye light shades on fresh goods, or to strengthen the first liquor.† It should be remarked, however, that light shades obtained by this means have not so much

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* Hellot recommends even as much as six pounds of weld, but this is two pounds too much. The quantity of weld, however, should be proportioned to the depth of shade.

† Some dyers add to the weld a little quicklime and ashes, which favor the extraction of the coloring matter, and heighten its color, but this renders it liable to change by the action of acids.

vivacity as when fresh baths are used, proportioning the quantity of weld to the shade desired. If the cloth is wanted of a golden yellow color, on its leaving the weld bath, it should be turned through a slight bath of madder.

WITH FUSTIC.—The fustic should be ground or rasped, and enclosed in a bag, that it may not mix up in the cloth. To dye the color proceed as follows:—

1. In a boiler of sufficient capacity to hold twenty-five buckets of water, put fifty pounds of fustic, which should be boiled from two to three hours.

2. Empty the liquor into a wooden pipe or tun; boil the fustic a second time, and empty this also into the tun. The liquor should never be allowed to remain with the wood in the boiler, not even for a quarter of an hour, because the wood would, in a great measure, re-absorb the color. The liquor, therefore, should be laded off while boiling, and strained through a wicker basket with a cloth. For like reason, care should be taken that no wood or chips be thrown into the tun which contains the liquor.*

WITH QUERCITRON.—*Dr. Bancroft*, who has had great experience in dyeing with quercitron bark, prescribes three or four ounces of alum, without tartar, as the mordant for a pound of woolen goods. Boil the cloth in it a couple of hours; take out, drain, *but do not rinse:* then dye it in a bath of quercitron bark of an equal weight with the alum used.† At the close of the dyeing, throw in a pound of whiting for a hundred pounds of goods.

BUFF YELLOW.—Although buff yellow may be dyed with the usual yellow drugs, it can be more permanently dyed by means of iron stain. Dip the cloth in water impregnated with a strong solution of iron slowly made in aqua-fortis, diluted with an equal quantity of water; which when

* The fustic liquor, should be used not later than two or three days after it is made, for it is apt to spoil.

† "I am fully persuaded," says Mr. Cooper, "that the proportion of quercitron bark prescribed by Dr. Bancroft, is greatly too small for a full color: twice the quantity he prescribes would not be too much." The bark used by Dr. Bancroft, for his experiments, consisted, we dare say, of selected samples.

made must be used in a few days or else kept from the air. It will require two gallons for one hundred pounds of cloth, mixed with a sufficient quantity of warm water. Turn the cloth in it for a quarter of an hour. Drain: then run through a mixture of lime water, three or four pecks of lime to water sufficient to work the cloth in: or instead of lime use three pounds of potash to the same quantity of water: then expose the cloth, after washing, to the air, until the greenish color turns to a buff. Repeat these alternate dippings, washings, and airings, till the desired color is produced.

For common goods, dissolve for one hundred pounds of goods, twenty pounds of copperas in water: work the goods in this liquor (warm) for a quarter of an hour: then in a bath of lime water or potash. Proceed as above, always airing the goods to give time for the color to become buff, after each immersion in the lime or the potash liquor. This color diluted, is a most excellent ground for grays, and for all colors in which gray is meant to form a part.

HENDRICKS'S PATENT PROCESS.*—Mr. Hermon Hendricks, of Dunkirk, France, informs us that he obtains a beautiful yellow on wool or woolen cloth, "by means of the *double decomposition* of chromate of potash, or bichromate of potash, or chromate of soda, and a soluble salt of lead." In order to obtain this color, the cloth must be passed through the following series of baths, and in the order that they are numbered:—

Bath No. 1.—This bath is prepared with acetate of lead (or any soluble salts of lead), of the specific gravity of two degrees of the areometer. This bath is to be heated by steam, *not condensed*, and of a temperature of from 100° to 105° F.

Bath No. 2.—This bath is prepared with chromate of potash, or bichromate of potash (the chromate of soda will answer equally well), of the specific gravity of three degrees.

* Mr. Hendricks's process for dyeing blue on wool without indigo, will be described in the next chapter.

This bath is heated by means of steam, like the foregoing, or bath No. 1. This bath, however, is only to be heated to 160° F.

Bath No. 3.—This bath is composed of water, and may be used at a temperature of from 60° to 70° F.

Bath No. 4.—This bath is composed of water slightly acidulated, with acetate of lead, so as to have only a very faint taste. The cloth, says the patentee, after passing through the baths in regular succession, is finished in the usual manner.

Mr. Hendricks claims *as of his invention*, "the application of the process of the double decomposition of chromate of potash, or bichromate of potash, or chromate of soda, and a soluble salt of lead, to the dyeing of wool and woolen fabrics yellow." This process, however, is not of the invention of Mr. Hendricks. We hope the gentlemen will waive all claim to the composition of bath No. 3.

CHAPTER III.

OF BLUE, ORANGE, AND GREEN.

PROCESSES OF DYEING BLUE ON WOOL.

Woad or Pastel Vats, their Construction, &c.—Setting and Managing the Vats—Precautions to be observed—Putrefaction, and the Remedy—Köber's Improved Woad Vat—Hendricks's Process for superseding the use of Indigo in Dyeing Blue on Wool—Orange—Green—Another Process for Dyeing Green.

WOAD OR PASTEL VATS.—The pastel or woad vats, are set in the ground, and project above the floor, no higher than is necessary for the dyers to work them conveniently. They are nine or ten feet deep, and from five to six feet in diameter; made of staves six inches broad and two inches thick, bound with iron hoops about three feet asunder. The bottom instead of being made of wood, may be made with cement, such as lime, pounded bricks and leached ashes. The drugs of which the vat is composed, are stirred up by the rake.*

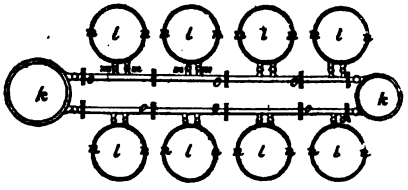
The cloth is worked by means of hooks fastened to the end of a staff. An iron hoop covered with a net whose meshes are about an inch square, is let down into the vat to prevent the cloth from mixing with the grounds or sediment at the bottom.† Sometimes brandy puncheons, or well cleansed oil puncheons, are used, as vats for this purpose; but they should be iron hooped, and the hoops painted. The boiler or cauldron should be placed near the vat.

Fig. 20, represents an apparatus suited to the purpose of vat dyeing, by which any number of vats may be heated at once. The heat is conveyed by the fluid along the pipes and round a casing or interior tube placed in the vat, and may be

* Cooper on Dyeing, p. 35.

† Berthollet on Dyeing, vol. II. p. 54.

Fig. 20.



increased or diminished by turning the stopcock. *k*, *k*, represents a generator and counter generator. *l*, *l*, *l*, *l*, represents the vats in section. *n*, *n*, the circular tube or casing within which the hot fluid circulates. *m*, *m*, the stopcocks through which the fluid passes into the casing of the vats. *o*, *o*, *o*, *o*, are the pipes through which the fluid circulates.

The process for setting a woad vat is as follows:—

1. For a vat of nine feet deep by five feet and three quarters over, take about four hundred weight of woad, break it into small pieces, and throw it into the vat. Boil in the contiguous boiler, thirty-three pounds of weld with a sufficient quantity of water for the vat; add as much madder, and about a bushel or a little more of bran; continue the boiling for half an hour; add a few buckets of water; let the liquor settle, and take out the weld;* turn the liquor into the vat, stirring constantly; stir the liquor well afterwards in the vat for a quarter of an hour, to mix together all the contents; then cover up the vat close for six hours; open it at the end of that time; stir up the contents for half an hour; do so every three hours for three or four times.

2. When blue veins begin to appear, add between eight and nine pounds of good *fresh burnt* lime; lime that has remained exposed to the air for some time is good for little; if no other can be got, use the more of it; but spent lime is worse than useless. The vat now puts on a new character; its color is much deepened, and the vapor from it is more penetrating. When indigo is used with the woad vat, this is the point of time when it is to be put in, being first carefully ground; the quantity depends on the shade of blue required: from five to five-and-twenty pounds may be used.

3. On plunging in the rake, if a fine blue froth appear on the liquor, the contents should be well stirred up twice in six hours, and one or two pounds more of lime added; the surface must not be exposed to the air, any longer than is necessary to stir it; indeed it would be an improvement to have an opening in the cover that would just admit the rake, and a lid to shut down upon the opening. During all this time, the warmth is to be preserved in the liquor by covering it as close as possible.

4. The vat is in proper order for dyeing, when the sediment, and the body of the liquor are of a fine brownish green color—when the froth at the top exposed to the air, is of a fine blue—when a pattern immersed for a couple of hours in the

* "The liquor need not be very clear; if some of the bran and madder should go into the vat, I see no harm it can do."—*Cooper.*

liquor, comes out a grass green color, and gradually turns blue on exposure to the air.

It often occurs that a vat will not furnish a good color because it is too cold; occasioned by its having been overcharged with lime. Sometimes, also, the vat runs into a state of putrefaction.

In the first case, all that is necessary, is to heat part of the liquor, and return it hot into the vat, stirring up the contents for twenty minutes with the rake, and then covering it up closely. In the second case, reheat in the boiler part of the liquor; then add about a couple of pecks of bran, and four or five pounds of madder; stir these in the liquor, but do not rake up the sediment; and let remain covered. If the fault is trifling, the addition of the bran and madder will answer without raking. Let the vat now rest for a day or two, or even longer.

Should the contents of the vat putrefy, which may be known by the disappearing of the blue veins, and of the blue froth—by the rusty color of the liquor—by the sediment spontaneously beginning to rise—and by the fetid smell of the vat, lime must be added, and the grounds raked up: in two hours more, a little lime may be added, and the sediment stirred again; and so on, cautiously, till the evil be remedied.*

It is evident, then, that the skill in treating the woad-vat, depends on the proper addition of lime to prevent the hasty fermentation of the vegetable substances employed to disoxygenate the indigo, which would destroy the coloring matter; and to dissolve a part of the coloring matter so disoxygenated. The lime is gradually precipitated in the form of pulverized limestone by the addition of carbonic acid proceeding from the gradual fermentation of the madder, the bran, and the decoction of weld. Hence the necessity of now and then adding a small quantity of fresh lime, to renew the necessary solvent.

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* Some dyers add crude tartar to a vat so circumstanced, with a view to neutralize the lime; but this practice does not appear to be sanctioned by common usage.—*Cooper.*

Before the dyer enters the goods, the vat should be stirred, and left to settle for about two hours. He then lets down his cross, net, or trellis, to prevent the sediment and cloth coming in contact. The wool, whether unspun, or in the yarn, or in the piece, should be pressed out of warm water before entering it in the vat. It is not easy to dye an even color in a full, rich vat: it is better done for bright colors, by making use of vats that have been partly worked, and are beginning to cool, finishing in a fresh vat. When goods have been dyed blue, they should be carefully washed to get rid of all color that adheres mechanically only; and indeed they would be improved by being fulled with a small quantity of white soap, which has no injurious effect upon the blue, and cleans the cloth from any superfluous sediment.

No distinction has been made, in the foregoing description, between the pastel and the woad vat, because the process is the same in both vats.* In setting the woad vat, the old liquor of a spent madder bath may be used to save madder, which like the weld is of no use as a coloring substance, but only as a fermenting ingredient. In this point of view, the weld, especially in this country, might be saved, by increasing the proportions of madder and bran.†

It is thought that five pounds of indigo, of the best quality, contain as much coloring matter as two hundred pounds of woad. The woad vat should never have lime added to it just before it is reheated. In Holland, to save the trouble of reheating the vat repeatedly, they have metal vats, six feet deep, four and a half at the bottom, and five and a half at the top; the bottom part for two and a half feet upward, is made of lead, and the upper part for three and a half feet is of copper. The vat is surrounded with a brick wall six inches thick, and the intermediate space is filled with warm embers or wood ashes, high enough to keep up a continued

* The woad vat is often used, to give a blue ground to black.

† "I do not think," says Mr. Cooper, "quercitron bark would be a proper substitute, because it is more astringent, and not so fermentable as weld, but I think weld might be superseded by common *hay*."

moderate heat. When cold, the embers can be removed, by taking out a brick or two at the bottom.

The lime should be slacked before using it. There is no advantage in letting the bran liquor become sour, either in the vat or out of it. These instructions are all that are, principally, necessary when it is intended to dye blue with woad, either with or without indigo. Woad of itself produces a durable blue, but without indigo, a large quantity of it must be used to obtain a color of any considerable depth, for reasons already stated. But by mixing woad with indigo, vats are formed very rich in color, which are almost the only ones in use for dyeing wool and woolen goods. For further details on this subject, see chapter V. Part III.

KÖBER'S IMPROVED WOAD VAT.—In a patent granted to Mr. Charles Köber, of Leeds, on the 7th of March, 1840, for improvements in the mode of fixing color on wool, we find a claim to "the use of soda and bran for dissolving the indigo in the vats for dyeing blue, whereby the indigo is better fixed in the wool and at a less expense than is incurred by the use of woad, madder, and bran," which are usually employed. This patent contains two other claims, the one relating to green, and the other to the mode of fixing color on wool or other goods. The first (green) is described in this chapter, under the article *Green*. The second, or the mode of fixing color on cloth, under the title of *Köber's Mordant for Wool*, and will be described in the next chapter.

The improvement on the woad vat, or mode of dyeing blue by the use of woad above referred to, is as follows:—

In a seven feet vat, the water being heated to 125° F., throw in sixty-five pounds of bran, thirty-five of common soda, (which has about 23 per cent. of carbonate of soda,) four of indigo, and the usual quantity of lime. The vat is worked from 110° to 118° F. three or four times during the day, without stirring; and in the evening heated to a temperature of 125°. Four pounds of lime, six of bran, and five of soda, are now added, with such an additional quantity of indigo as may be required for the following day; after this addition the vat is stirred. If the vat has been working during

the day, the above quantity of lime, bran, and soda, is added every evening, together with the requisite quantity of indigo. It would be difficult to state the exact quantity of indigo required, as any amount, from half a pound to twenty-five pounds, may be added, according to the shade of color required to be produced the following day. After proceeding in this manner for *eight or ten weeks*, the sediment is removed, and with the liquor in the old vat, the operator sets a new one, adding thirteen pounds of bran, and ten of soda, with as much lime and indigo as may be required. The use of lime being to check the fermentation produced by the bran, it is impossible to state the exact quantity which may be required; but enough must be used to check the fermentation in the vat to such a degree as will deprive the indigo of oxygen, without an immoderate fermentation, which is very prejudicial. The vat, in which the soda is used, must be perfectly yellow; that is to say, the indigo must be perfectly deprived of its oxygen, or, as it is generally termed, the indigo must be *sprung*, in which case the vat appears yellow. By the use of soda-ashes, (which have about 46 per cent. of carbonate of soda,) instead of common soda, half the quantity will produce the same effect. Pearlash may likewise be employed, if the price will admit of it; and fine sharps may be used instead of bran.

The patentee claims the use and application to indigo of soda and bran, or soda-ashes and bran, either by themselves, or mixed with woad and madder, "whereby," he says, "the color is fixed in the wool better and cheaper, than by the use of woad and madder alone."

A blue dye may likewise be given by a solution of indigo in sulphuric acid. This process was discovered by Barth, at Grossenhayn, in Saxony, about the year 1740, and is hence called the Saxon blue dye. The chemical nature of this process has been already fully explained in chapter V. Part III., article *Preparation of Chemic.*

With sulphate of indigo, not only blues of every shade are dyed, (as we shall hereafter see) but also green, olive, gray, as also a fast ground to logwood blues; for the latter purpose

the preparatory boil is given with alum, tartar, sulphates of copper and iron, and the blue solution; after which the goods are dyed in a logwood bath containing a little potash.

HENDRICKS'S PATENT PROCESS.—In the last chapter, when treating of yellow, we referred to Mr. Hendricks's process for dyeing blue on wool without indigo. We shall now give that process, and which the patentee observes is "intended to be employed as a substitute for indigo in dyeing woolen and other materials of a blue color; or as a foundation for black and other colors, in which blue forms the base or fundamental tint."

The process of preparing and applying this dyeing material is soon told; but the patentee, from what motive, is best known to himself, has thought proper to extend his description to such an enormous length, that a literal copy of the document could not be obtained from the Inrolment office for a smaller sum than about eighty-five pounds sterling, or about four hundred dollars.

A mixture is made of equal parts, by weight, of animal substances and potash, there having been previously mixed with the potash scraps of cast or forged iron, in the proportion of one part scraps to fifty parts potash. The animal substances to be employed, are dried blood, horn scrapings, horns and hoofs of animals, hair, feathers, refuse woolen, leather, leather-cuttings, and bones. This mixture is calcined in a close cylinder, and agitated during the operation. The calcining process being complete, the calcined matter is taken out of the cylinder and cooled in conical moulds. When the material so operated upon has become cold, it is to be moistened: water being used for the first process, and afterwards the weak solution of prussiate, arising from the washing of the calcined substances,—in the proportion of one quart, to each pound of calcined matter, stirring with the rake at intervals. After a few hours, the calcined matter is again placed in the cylinder, filling it three parts full; water is then admitted for the first process, and the weak solutions of prussiate afterwards.

A reservoir on one side of the cylinder (having a cock), is

now filled, half full, with a mixture of one part sulphuric acid, and ten parts water, the calcined matter is then boiled up, and when boiled sufficiently is run off and filtered. The process of boiling and filtering is to be repeated several times; after which some concentrated solution of potash is added, and the materials again boiled up and filtered; from thence it is poured into a suitable vessel and crystalized; and when the crystals are formed, the prussiate of potash is obtained.*

The cloth to be dyed is passed through the following *eighteen* baths, in the order in which they are enumerated:—

1. *The Acid Bath.*—This is composed of one part muriatic acid to fifty parts of water, and is employed at a temperature of from 77° to 100° F.

2. *The Alkaline Bath.*—This is composed of one part carbonate of soda to one hundred parts water, and is employed at a temperature of from 77° to 100° F.

3. *The Alkaline Bath.*—This is composed of carbonate of soda, of the strength of three degrees of the areometer, for salts, and is employed at a temperature of from 77° to 100° F.

4. *The Ferruginous Bath.*—This is composed of proto-salts of iron (as for instance, the neutral proto-muriate), of the strength of six degrees, and is employed at a temperature of from 144° to 167° F.

5. *The Protoxided Ferruginous Bath.*—This is composed of proto-salt of iron, and is employed at a temperature of from 144° to 167° F.

6. *The Alkaline Bath.*—This bath is the same as No. 2.

7. *The Carbonated Saponaceous Bath.*—This is composed of soap neutralized, of the strength of ¼ of a degree, and is employed at a temperature of from 190° to 212° F.

8. *The Prussiate Bath.*—This is composed of prussiate of potash, and muriatic acid, mixed according to the proportion required, to vary the color, and is employed at a temperature of from 122° to 124° F.

9. *The Prussiate Bath.*—This is composed of prussiate of potash and muriatic acid, of the strength of one degree, and is employed at a temperature of from 122° to 144° F.

10. *The Protoxided Ferruginous Bath.*—This is composed of proto-muriate of iron, of the strength of four degrees, and is employed at a temperature of from 190° to 212° F.

11. *The Per-oxidated Ferruginous Bath.*—This is composed of any of the per-salts of iron, of the strength of a ¼ of a degree, and is employed at a temperature of from 122° to 144° F.

12. *The Acid Bath.*—This is composed of water slightly acidulated with muriatic, or any other acid, except nitric acid (which would turn the articles yellow), and is employed at a temperature of from 144° to 167° F.

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* The mode of making prussiate of soda is precisely the same as that of making prussiate of potash, except that soda is substituted for potash.

13. *The Ammoniacal Bath.*—This is composed of one part liquid ammonia to two hundred parts water, and is employed at an ordinary temperature, or hand heat.

14. *The Aluminous or Tin Bath.*—This is composed of the muriates or alumine of tin, of the strength of ¼ of a degree, and water charged with an earthy carbonate, such as lime, and is employed at a temperature of from 112° to 144° F.

15. *The Red Bath.*—This is composed of madder and is slightly acidulated with boracic acid, and is employed at a temperature of from 190° to 212° F.

16. *The Hot Stove Bath.*—This is employed at a temperature of from 122° to 144° F., for increasing or diminishing the intensity of color.

17. *The Ammoniacal Bath.*—This bath is the same as No. 13, and is employed at an ordinary temperature, or hand heat.

18. *The Acid Vapor Bath.*—This is composed of either sulphuric, muriatic, or acetic acid, and is employed at a temperature of from 167° to 190° F.; the goods are then finished in the usual manner.

The patentee claims, *first*,—the process of calcining and constantly agitating the mixture of animal and other substances, in closed cylinders or other closed vessels, for producing the prussiate of potash, and the prussiate of soda. *Secondly.*—Fixing the oxide of iron on textile or other substances, by means of single or double decomposition of the protosalt of iron; fixing the deutoxide of iron on the like substances, by immersing them in a bath, formed of the protoxide of iron, in a neutral state; producing a uniform oxygenation of the protoxide of iron by means of a current of warm air, and the use of an alkaline and saponaceous bath, before uniting the oxide of iron with the ferrocyanic acid; and afterwards by passing them into a bath composed of a soluble ferrocyanate or prussiate; and thus producing a uniformity of color; and the employment of a stove or bath, for reviving, increasing, or diminishing the intensity of color, when dyeing blues without indigo.

ORANGE.—Orange is a compound of three parts of yellow and five of red. Dye in the scarlet bath, with the addition of quercitron.

GREEN.—Green is composed of three parts of yellow and eight of blue. The blue should be dyed first, whether the blue vat be used, or the sulphate of indigo:* for the yellow

* See chapter V., Part III., article *Preparation of Chemic.*

dye is injured both by the alkali of the one, and the acid of the other.

The pastel vat is sometimes employed, to give the blue ground for this color, but for some kinds of green, the chemic or sulphate of indigo is preferred. The blue ground which is given by the vat, should be proportioned to the kind of green wanted. Thus, for *drakes-neck green*, a deep blue is required, and for *parrot-green*, a sky-blue ground. It is easy to see that a great variety of greens may be produced, not only according to the proportions of the indigo and yellow dyes employed, but according to the nature of the yellow substance. For obtaining a decided green, however, fustic is preferred to the other yellow coloring substances, because its color is less affected by sulphuric acid. Fustic, also, agrees well with alum as a mordant.

In order to avoid this effect with quercitron bark, Bancroft directs us to dye the stuff blue at first, to rinse well, and give afterwards a preparation or mordanting composed of three parts of washed chalk, and ten or twelve of alum, for 100 pounds of cloth. It is to be boiled for an hour. Then without renewing the bath, 10 or 12 parts of quercitron are introduced, and the dyeing is continued. At the end of a quarter of an hour, one part of chalk is added, and this addition is repeated at intervals of six or eight minutes, till a fine green color is obtained.*

It is mentioned as a fault in Saxon blue, that it has a greenish cast, proceeding probably from the slight alteration that sulphuric acid produces on the particles of indigo; it, likewise, as well as Saxon green, is said to have less durability than the blues and greens obtained by means of the vat.

KÖBER'S PROCESS OF DYEING GREEN.—In this chapter, article *Köber's Improved Woad Vat*, we referred to an improved method of dyeing green, as Mr. Köber calls it, and which method we will now describe; although, we

* Elements of the Art of Dyeing, vol. II. p. 266.

are satisfied, that the same thing was done in this country, long before the date of Mr. Köber's patent.

The *invention* consists in dyeing the wool blue, and then manufacturing it from the blue wool, so as to make it what is called *partly-finished cloth*, with a white, or colored list, and then adding the yellow ingredients, to the cloth, instead of to the wool; "by which means," he says, "a perfectly fast green color will be obtained, similar in appearance to wool-dyed green, but much faster. Every kind of yellow ware may be used, but fustic is preferred; and in order to fasten the color, hydrochloric acid, saturated with tin, is used, to which is added as much water as will give the solution a specific gravity 1·2612, or 80° Baumé; and of this solution from six to seven pounds is used to every hundred weight of cloth, besides the usual quantity of alum and tartar." This solution could not be applied to wool in fleeces, as it would be destructive to the use of soap, and consequently to the milling process.

CHAPTER IV.

OF PURPLE, BROWN, GRAY, AND BLACK.

PROCESSES OF DYEING PURPLE ON WOOL.

Processes of Dyeing Purples, Violets, Lilacs, Colombines, &c.—Brown, Gray, Black—Köber's Mordant for Wool—General Remarks on these subjects.

PURPLE.—Purples, violets, lilacs, colombines, &c., having been already treated of extensively, our observations in this place will, consequently, be brief.

Purple arises from the union of red and blue, in the proportions of five parts of red to eight of blue.*

According to Hellot and Berthollet, goods dyed scarlet, take a superadded blue dye unequally. They must be dyed of a light or sky blue first. Then give them a mordant or preparation liquor of alum and tartar, two ounces and a half of alum, and one ounce of tartar; work in this for an hour; drain, and cool; then run through a dyeing or finishing bath of cochineal, half or two-thirds as strong as a full scarlet bath, according to the shade of purple required.

Purple on wool may also be obtained in the following manner:—Alum four ounces, tartar two ounces, as the mordant or preparation for a pound of wool; boil for an hour and a half; drain, cool, and rinse: then enter it into a finishing or dye-liquor of three-fourths of a pound of madder, and two ounces of red wood for each pound of wool. Do not let the liquor exceed a heat of 145° F. Wince for an hour, drain, cool, rinse, and give one dip in the blue vat.

According to Homassel, purples and violets of the finest

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* See chapter VIII, Part III., article *Preliminary Observations*.

tints can only be made by means of a mordant or composition of *bismuth* dissolved in nitric acid. To make this solution, proceed as follows:—

Dissolve, gradually, in the strongest nitric acid, bismuth carefully reduced to a coarse powder in a mortar, taking care that there be no dirt, or extraneous matter, particularly no ferruginous matter. Add the powdered bismuth by degrees to the nitric acid, to the amount of three ounces of the semi-metal to the pound of acid: add no water, or sal ammoniac. When all is dissolved, pour off the clear into a bottle with a glass stopper. Make no more than is wanted to use at a time, for it is very apt to oxygenate by exposure to the air.

This mordant requires no alum or tartar; use about two ounces of this solution, in water, to the pound of cloth, and for bright colors, add also about half an ounce of cochineal to the pound of goods.

Violet does not require so deep a blue, or so deep a red as purple. Frequently these colors are finished in a scarlet bath, adding the quantity of tartar and cochineal that may be thought necessary.

Another method of obtaining violet, is to give a light blue ground in the vat; then half an ounce of cochineal, and two ounces of the solution of bismuth, to the pound of goods. Boil for an hour. For light violet give half an ounce of cochineal per pound of goods, (after having given in the first instance, a preparation of two ounces of solution of bismuth) and boil for half an hour; without any previous blue ground.

For lilacs, pigeons-breast, &c., the goods may be run through liquors that have served for violets, adding a little alum and tartar. The blue ground is made of such a tint, and the cochineal added in the finishing, in such proportion as the color requires. When a reddish shade is wanted, such as for peach-blossom, a little of the scarlet composition or nitro-muriate of tin should be added. If a very bright tint be desired, though the quantity of cochineal may be diminished, yet the quantity of tartar must not be decreased.

From the foregoing observations, it is obvious that the various shades of all the colors above mentioned, may be obtained by slight variations of the blue ground, and of the proportions of cochineal, alum, and tartar. Also, by using Brazil, madder, or a mixture of these, with or without the

cochineal, all of which the practical dyer understands proportioning, perhaps, much better than the writer.

BROWN.—Brown is uniformly a tertiary compound or hue in shade, in which red and yellow predominate.

Brown may be produced by direct dyes. The decoction of oak bark dyes wool a fast brown of different shades, according to the concentration of the bath; but the color is more lively with the addition of alum. Walnut peels also, when ripe, contain a dark brown dye-stuff, which communicates a permanent color to wool. The older the decoction the better. The goods are dyed in a lukewarm bath, and need no mordant, though they become brighter with alum. Or this decoction may be combined with the madder or fustic bath, to give varieties of shade. This dye presents a vast variety of tints, from yellow and red to black brown, and is produced either by mixtures of red, yellow, and blue, or of yellow, red, and black. We shall here notice only the principal shades; leaving their modifications to the skill of the dyer.

1. The goods should be boiled, in the first instance, with one-eighth their weight of alum and sulpho-tartrate of iron; washed, and winced through the madder bath, which dyes the portion of the goods imbued with the alum, red, and that with the salt of iron, black; the tint depending upon the proportion of each, and the duration of the madder bath.

2. Brown, nearly similar to that described, may be produced by boiling with the goods, two ounces of alum and one ounce of common salt to the pound, and then dyeing in a bath of logwood containing either sulpho-tartrate, acetate, or sulphate of iron. Or the goods may be boiled with alum and tartar, dyed in a madder bath, and then run through a black bath of iron mordant and galls, or sumac. Here the black tint is added to the red till the proper hue is obtained. The brown may be produced also by adding iron liquor to the madder bath, after the goods have been dyed in it with alum and tartar.

3. A superior brown, of the foregoing kind, may be obtained by boiling every pound of goods with 2 ounces of alum, dyeing in cochineal, then changing the crimson thus

given into brown, by turning through the bath after acetate of iron has been added. Instead of the cochineal, archil, or cudbear, with a little galls or sumac, may be used.

4. Woolen goods may also receive a light blue ground from the indigo vat, then be mordanted with alum, washed, and turned through a madder bath till the wished-for brown be obtained. For the deeper shades, galls or sumac may be added to the paler Brazil-wood, with more or less iron mordant. Instead of the indigo vat, chemic-blue may be employed to ground before dyeing with madder, or 5 pounds of madder, 1 pound of alum, and a solution of one-tenth of a pound of indigo in sulphuric acid, may be used with the proper quantity of water, for 20 pounds of wool; for dark shades, some iron mordant should be added.

5. Various shades from *mordoré* and cinnamon to chestnut-brown, may be obtained, by first, boiling the goods with alum and tartar; then passing through a madder bath; and afterwards through one of weld and fustic, containing more or less iron mordant, according to the proportions of the materials.

6. Bronze colors may be obtained after the same manner, from the union of olive dyes with red. The process is as follows:—For 25 pounds of cloth, take 4 pounds of fustic chips, boil for 2 hours, turn the cloth in this bath for an hour, heave out, and drain. Now add to the bath from 4 to 6 ounces of sulphate of iron, 1 pound of madder, or 2 pounds of sandal-wood; enter the cloth and work till the desired shade be procured. By changing the proportions, and adding an iron mordant, other tints may be produced.

GRAY.—Gray, is the union of the three primaries, red, yellow, and blue, by which they neutralize each other, and cannot therefore be properly termed a color.

The materials used in dyeing permanent grays, are essentially the tannic and gallic acid or other astringents, with the sulphate or acetate of iron.* To procure an ash-gray, proceed as follows:—

1. 30 pounds of goods: take one pound of galls, ½ pound

* See chapter II. Part III., and chapter I. of the same Part, article *Iron*.

of crude tartar, and 2½ pounds of copperas, and boil in from 70 to 80 pounds of water. When well boiled, the goods are entered and kept at a boiling heat, for half an hour, then taken out.

2. The bath is now refreshed with cold water, the copperas is added, and as soon as dissolved, the goods are entered, and fully dyed.

3. Or proceed thus. For 36 pounds of wool or goods; 2 pounds of tartar, ½ pound of galls, 3 pounds of sumac, and 2 pounds of copperas are taken. The tartar being dissolved in 80 pounds of boiling water, the goods are entered and worked for half an hour, and then taken out.

4. The bath being filled up to its former level with fresh water, the decoction of the galls and sumac is poured in, and the goods entered and boiled for half an hour. They are then taken out, while the copperas is being added and dissolved; after which they are again entered, and dyed with a gentle heat.

5. If it be desirable to have the gray of a yellow cast, then, instead of the tartar, its weight of alum is to be taken; instead of the galls one pound of old fustic; instead of the copperas ¾ths of a pound of Saltzburg vitriol, which consists in 22¾ parts, of 17 of copperas, and 5¾ of sulphate of copper; then proceed as above directed. Or the goods may first be stained in a bath of fustic, next in a weak bath of galls with a little alum; then taken out and a little common vitriol added, previously dissolved in a decoction of logwood; and in this bath the dyeing is completed.

6. *Pearl gray* is produced by passing the goods first through a decoction of sumac, and finishing in a weak bath of weld, containing a little alum.

7. *Mouse gray* is obtained, with the same proportions as for ash-gray; a small quantity of alum is introduced.

8. *Tawney gray*, iron gray, and slate gray, may be produced by giving the goods a ground in the blue-vat. They are then passed through a bath of boiling sumac with galls, and through the same bath, at a lower temperature as soon

as they have received the proper quantity of the solution of iron.

With these observations on gray, and the modes of producing the various shades, we shall proceed to make a few remarks on the best modes of producing black.

BLACK.—As we have already, when speaking of cotton, treated of the best methods of obtaining black;* and as we shall treat of this color in the next part, when speaking of silk, we need not enter into any very lengthy details here. The proportions of the substances for producing this color, are so various, and depend so much on the local, the occasional, and the relative dearness and cheapness of them, that one process may be expedient at one time and place while it is not so at another. But it should, however, be remarked that these difficulties are not, at the present day, of so serious a character as they were a few years ago. The French method of obtaining black on woolen goods is nearly as follows:—

1. The goods should first be dyed blue; then take 18 pounds of logwood, and as much of galls for 100 pounds of goods. The logwood (ground) and galls should be put in bags and boiled for 12 hours. One-third of this liquor is to be laded into another boiler, with two pounds and a quarter of verdigris. The cloth is soaked in this for two hours at a moderate heat, but not boiling. It must be constantly stirred for two hours. It should then be taken out, drained and cooled on the folding board, running it over from hand to hand quickly.

2. To the liquor in the bath, now add another third of the decoction of logwood and galls, and nine pounds of copperas—lower the heat—let the copperas dissolve, and in half an hour enter the goods, and reel briskly for one hour. They should, now be taken out, drained, and cooled, or aired, on the folding board.

3. The bags in the gall and logwood liquor, are now well pressed, and the last third of the decoction turned into the dyeing bath, to which also about twenty pounds of sumac is to be added. Bring the liquor to a boiling heat, and let it so continue for a quarter of an hour; then throw in two pounds and a quarter of copperas, and when dissolved let cool a little. Now enter the goods and reel briskly for an hour, drain, and air on the folding board, then rinse in clear water; after which let air for some time.

4. Raise the heat of the bath nearly to ebullition; enter the goods and reel for an hour; drain, cool, and air, wash in the river until the water comes off colorless.

5. A bath of weld is now prepared, and which should only be permitted to boil for a few minutes; cool with a little cold water; enter the goods and reel for an hour; drain, cool, and wash.

On the foregoing process it may be observed, that if the

* See chapters I. II. and IX., Part III., and chapter III., Part I., article *Logwood*.

cloth be dyed a good blue first, the proportions of ingredients are perhaps rather large. Great advantage also is to be found in airing well between each dipping. Indeed black is never perfect until well exposed to the air. Lewis and Berthollet, are of opinion that the last working in the weld liquor is superfluous; and in this they are, perhaps, right. The proportion of logwood might be a little increased at the expense of the other ingredients; because the soft and velvety lustre of the color on the goods, depends more on the logwood than on the galls and sumac, notwithstanding that these last afford a more permanent dye. Mr. Cooper is of opinion that the last working should be in the liquor with a small quantity of Gallipoli oil, to give the soft feel to the cloth, which, he says, is so great a recommendation; always premising an effectual scouring.*

When fine cloth is to be dyed black, care must be taken not to let it hang on the reel. The cloth must be thrown off the instant the last comes up; otherwise its own weight when wet and hot would fill it with wrinkles that could never be removed. The same precaution must be taken when the cloth is on the floor, to draw it between two men over a roller by the lists; each taking hold of a selvige with the left hand. This operation must be continued till the goods become cold, and before which they must not be returned to the bath.

Some dyers proceed thus to obtain black:—Take 6 ounces of logwood, as much sumac, and 2 ounces of fustic for each pound of goods; boil these for two hours; then a little cold water is thrown in to cool down, and the goods entered and reeled for two hours. They are now taken out, when three ounces and a half of copperas and half an ounce of verdigris, are to be added to the pound of goods. When these are dissolved, stir up and enter; work for half an hour, rather under boiling heat. The goods are now taken out, cooled, and well aired. These operations are to be repeated two or three times more; then drain, cool, air, and wash.

KÖBER'S MORDANT FOR WOOL.—In chapter III. of this Part, article *Köber's Improved Woad Vat*, we referred to a mode of fixing color on wool, patented in England, in March, 1840, by Mr. Charles Köber, of Leeds. We shall now describe this part of Mr. Köber's improvements.

* Cooper on Dyeing, p. 89.

The improvement consists in the use of bichromate of potash, as a medium for uniting the coloring ingredients, used in dyeing, with the wool, "whereby" he is, he says, "enabled to obtain a much faster, brighter, and cheaper color, than by the ordinary mordants used, such as sulphate of iron, and sulphate of alumina, and potash, or, as they are commonly called, copperas and alum." Again, "In consequence," he says, "of the great affinity of bichromate of potash for wool, as well as for the coloring ingredients, a comparatively small quantity will fix the color; that is to say, one pound of bichromate of potash can be used instead of from three to four pounds of alum, or copperas; besides which, the color produced by the use of bichromate of potash is fast in alkalies and air, and better resists the operations of scouring and the milling process; and less coloring ingredients are used than by the ordinary mode, because the color produced thereby, being faster, no loss of color will take place when scouring the cloth with soap; *and the fibres of the wool, in the dyeing of which bichromate of potash is employed, will not be injured, as they have hitherto been*, by the acids contained in alum or copperas; and, on the contrary, the cloth will be softer, and easier to be scribbled and milled; and, consequently, the same quantity of wool will produce a greater and better quantity and quality of cloth than by the method usually employed. The ordinary coloring ingredients are employed in conjunction with the bichromate of potash, and as every different shade and color requires a different proportion of ingredients, and the dye-wares differ so much in quality, that sometimes a double quantity of them is required, it is impossible to state the different proportions in which the bichromate should be used with them, the requisite amount varying according to the quantity of ingredients to be fixed on the wool." Mr. Köber, however, says, that he generally employs three pounds of bichromate of potash for preparing one hundred pounds of scoured wool; and he sometimes adds two pounds of argal or tartar. In the liquor, thus produced, the wool is boiled for one hour and a half; and on the next

day the color is filled up with as much of the coloring ingredients as the desired shade may require.

Mr. Köber claims as new "the use of bichromate of potash as a substitute for copperas, and alum, and other mordants."* This patent contains two other claims, the first of which consists in the use of soda and bran for dissolving the indigo in the vats for dyeing blue, whereby, he says, the indigo is better fixed in the wool, and at less expense than is incurred by the use of woad, madder, and bran.† The second claim is to the dyeing of the wool blue, then manufacturing it into cloth and then adding the yellow ingredients, by which, he says, a permanent green color may be obtained.—(See chapter III. of this Part, article *Green.*)

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* See chapter V., Part III.

† See chapter III. of this Part, article *Köber's Improved Woad Vat.*

PART FIFTH.

DYEING PROCESSES CONTINUED.

CHAPTER I.

OF BLACK, GRAY, AND BROWN.

PROCESSES OF DYEING BLACK ON SILK.

Difference between Wool and Silk Dyeing—What constitutes this difference—Cleansing the Silk from Gum—Galling—General Remarks on these operations—Processes of Dyeing Black on Silk, English, French, German, and American—Feather-Dyeing—Variety of Colors—Grays—Nut, Thorn, Black, Iron Grays, &c.—Brown—Various shades of Brown.

In this Part of the work, we shall give the principal colors and their compounds, in reverse order. In Parts III. and IV., we commenced by giving the primary colors, red, yellow, and blue, and then the secondaries, tertiaries, &c., and under each color, shades making the nearest approach to that particular color. We shall now, therefore, commence by giving black.

The coloring matters used in dyeing wool, are employed also to dye silk: but the method of managing the dyeing drugs upon silk is very different. For many colors, a heat above 100° F. must not be employed. The necessary dexterity in handling silk goods, *can only be acquired by long apprenticeship;* but as to the mere dyeing, that can soon be taught to any one accustomed to dye woolen goods. Indeed we never knew a good silk dyer who had not been a woolen dyer; a superior workman should be both.

According to the observations of Lewis, the processes that are employed for wool, yield only a rusty black to silk; and cotton is hardly dyed by the processes proper for wool and silk. The truth of these observations has been fully illustrated in the foregoing sections of this work, which precludes the necessity of enlarging much upon the subject here. 1. Wool has a great tendency to combine with coloring substances; but its physical nature requires its combinations to be made in general at a high temperature. The combination of the black molecules may therefore be directly effected in a bath, in proportion as they form; and if the operation be prolonged by subdividing it, it is only with the view of changing the necessary oxidizement of the sulphate, and augmenting that of the coloring particles themselves. Silk has little disposition to unite with the black particles. It seems to be merely by the agency of the tannin (see *Tannin* and *Gallic Acid*, chapter II., Part III.), with which it is previously impregnated, that these particles can fix themselves on it, especially after it has been scoured. For this reason, silk baths should be old, and have the coloring particles accumulated in them, but so feebly suspended as to yield to a weak affinity. Their precipitation is counteracted by the addition of gum, or other mucilaginous substances. The obstacle which might arise from the sulphuric acid set at liberty, is destroyed by iron filings, or other basis. Thus, baths of a very different composition, but with the essential condition of age, may be proper for giving this color to silk.

Silk naturally contains a substance called gum, which gives it the stiffness and elasticity peculiar to it in its native state; but this adds nothing to the strength of the silk, which is then styled *raw;* it rather renders it, indeed, more apt to wear out by the stiffness which it communicates; and although raw silk more readily takes a black color, yet the black is not so perfect in intensity, nor does it so well resist the re-agents capable of dissolving the coloring particles, as silk which is scoured or deprived of its gum.*

* See *Silk Bleaching, Scouring*, &c., chapter III., Part II.

Galling.—For the galling, galls equal to three-fourths of the weight of the silk are boiled for three or four hours; but on account of the price of Aleppo galls, more or less of the white gall-nuts, or of even an inferior kind called *galon*, are used. The proportion commonly employed at Paris is two parts of Aleppo galls to from eight to ten parts of galon. After the boiling, the galls are allowed to settle for two hours. The silk is then plunged into the bath, and left in it from twelve to thirty-six hours, after which it is taken out and washed in the river.*

Silk is capable of combining with quantities, more or less considerable, of the astringent principle; whence results a considerable increase of weight, not only from the weight of the astringent principle, but also from that of the coloring particles, which subsequently fix themselves in proportion to the quantity of the astringent principle which had entered into combination. Consequently the processes are varied according to the degree of weight which it is wished to communicate to the silk; a circumstance requiring some illustration. Silk loses nearly a fourth of its weight by a thorough boiling, and it resumes, in the light black dye, one half of this loss; but in the heavy black dye, it takes sometimes upwards of a fifth more than its primitive weight; a surcharge injurious to the beauty of the black, and the durability of the goods. The surcharged kind is denominated *English black*, because it is pretended that it was first practiced in England.† Since silk dyed with a great surcharge has not a beautiful black, it is usually destined for weft, and is blended with a warp dyed of a fine black.

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* To cleanse silk intended for black, it is usually boiled four or five hours with one-fifth of its weight of white soap, after which it is carefully beetled and washed.

† The commerce of silk goods is carried on in two ways; they are sold either by the weight, or by the surface, that is, by measure. Thus, says Berthollet, the trade of Tours was formerly distinguished from that of Lyons; the silks of the former being sold by weight, those of the latter, by measure. It was therefore their interest to surcharge the weight at Tours, and, on the contrary, to be sparing of the dyeing ingredients at Lyons; whence came the distinction of *light black* and *heavy black*. At present, both methods of dyeing are practiced at Lyons, the two modes of sale having been adopted there.

The peculiarity of the process for obtaining the heavy black, consists in leaving the silk longer in the gall liquor, in repeating the galling, in passing the silk a greater number of times through the dye, and even letting it lie in it for some time. The first galling is usually made with galls which have served for a preceding operation, and fresh galls are employed for the second. But these methods would not be sufficient for giving a great surcharge, such as is found in what is called the English black. To give it this weight, the silk is galled without being ungummed; and, on coming out of the galls, it is rendered supple by being worked on the jack and pin.

PROCESSES OF DYEING BLACK.—For the dyeing of raw silk black, it is galled in the cold, with the bath of galls which has already served for the black of boiled silk. For this purpose, silk, in its native yellow color, is made choice of. It should be remarked, that when it is desired to preserve a portion of the gum of the silk, which is afterwards made flexible, the galling is given with a hot bath of galls in the ordinary manner. But here, where the whole gum of the silk, and its concomitant elasticity, are to be preserved, the galling is made in the cold. If the infusion of galls be weak, the silk is left in it for several days.* Silk thus prepared and washed takes the black dye very easily, and the rinsing in a little water, to which sulphate of iron may be added, is sufficient to give it. The dye is made in the cold; but, according to the greater or less strength of the rinsings, it requires more or less time. Occasionally three or four days are necessary; after which it is washed, beetled once or twice, and then dried, without wringing.

* Berthollet on Dyeing, vol. II. p. 11. If heavy black is wanted, a third of the silk is put upon rods, and three times returned into the black ground; it is afterwards wrung with the pin over the copper; this is done by giving it three twists; in this manner three hanks may be wrung at once; because it should be done gently, and only to drain; it is again put upon rods, and suspended between two poles to air. While the first silk is airing, the second third part is dipped in the same manner, and afterwards the third portion, always in the same manner. It must be remembered that while the silk is on the rods, it should be turned from time to

Berthollet gives us the following account, with emendations, of Macquer's process, for dyeing 112 pounds of silk:—

1. 22 lbs. of Aleppo galls are boiled for two hours in a sufficient quantity of water. 32 lbs. of copperas, 13 lbs. of iron filings liquor, and 22 lbs. of country gum, are now put into a kind of two-handled cullender, pierced everywhere with holes. This kettle is suspended by two rods in the boiler, so as not to reach the bottom. The gum is left to dissolve for about an hour, stirring it from time to time. If, after this time, some gum remains in the kettle, it is a proof that the bath, which contains two hogsheads, has taken as much of it as is necessary. If, on the contrary, the whole gum is dissolved, from 1 to 4 lbs. more may be added. This cullender is left constantly suspended in the boiler, from which it is removed only when the dyeing is going on; and thereafter it is replaced. During all these operations the boiler must be kept hot, but without boiling.

2. The galling of the silk is performed with one-third of Aleppo galls. The silk is left in it for six hours the first time, then for twelve hours.*

Astringents differ from one another as to the quantity of the principle which enters into combination with the oxide of iron. Hence the proportion of the sulphate, or of any other salt of iron, and that of the astringents, should vary according to the astringents made use of, and according to their respective quantities. Gall-nut is the substance which contains most astringent; sumac, which seems second to it in this respect, throws down (decomposes), however, only half as much as sulphate of iron. The most suitable proportion of sulphate of iron appears to be that which corresponds to the quantity of the astringent matter, so that the whole iron precipitable by

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time to give it air. When the last third part is wrung, the first part is put in, and then the two others successively, three times, always airing each time. This is commonly called *giving the three wrings*, and these three wrings are called *one fire or heating*. The light blacks should also have three wrings to one fire.

* Lewis states that he has repeated this process of Macquer in the small way; and that by adding copperas progressively, and repeating the immersions of the silk a great number of times, he eventually obtained a fine black.

the astringent may be thrown down, and the whole astringent may be taken up in combination with the iron. As it is not possible, however, to arrive at such precision, it is better that the sulphate of iron should predominate, because the astringent, when in excess, counteracts the precipitation of the black coloring particles, and has the property of even dis solving them.

The action of astringents upon the goods is such, that if a black pattern be boiled with gall-nuts, it is reducible to gray.* The observation of Lewis may thence be explained. If cloth be turned several times through the coloring bath, after it has taken a good black color, instead of acquiring more body, it is weakened, and becomes brownish. Too considerable a quantity of the ingredients produces the same effect; to which the sulphuric acid, set at liberty by the precipitation of the oxide of iron, contributes.† It is merely the highly oxidized sulphate which is decomposed by the astringent; whence it appears that the sulphate will produce a different effect according to its state of oxidizement, and call for other proportions. Some advise, therefore, to follow the method of Proust, employing it in the oxidized state; but in this case it is only partially decomposed, and another part is brought, by the action of the astringent, into the lower degree of oxidizement.

The mixture of logwood with astringents, says Berthollet, contributes to the beauty of the black in a two-fold way. It produces molecules of a hue different from what the astringents do, and particularly blue molecules, with the oxide of copper, (verdigris) commonly employed in the black dyes; which appears to be more useful, the more acetate the verdigris made use of contains.

M. D'Angles asserts, that if the silk be previously dyed blue in the indigo vat, it will only take a mealy kind of black with the usual black dye; but if it first receives a blue ground with logwood and verdigris, a full velvety black is

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* Berthollet on Dyeing, vol. II. p. 22. † See chapters I., II., and IX. Part III.

obtained. He says also, that the walnut rind softens the silk.

On the whole, says Mr. Cooper, it appears to me that the best process for black on silk is, to give the silk a ground of walnut rind: then a deep logwood blue, which can be done by adding the verdigris to the logwood decoction and dissolving it therein; then the black dye, wherein the galls are in proportion to the copperas as four to one: this will take three separate immersions at least in the black dye, with subsequent airings and washings: always recollecting that if the goods of whatever kind are not aired out of the black dye, that black dye will be in part washed out.

DYEING FEATHERS BLACK, &c.—For 20 pounds of feathers, a strong decoction is made of 25 pounds of logwood in a proper quantity of water. After boiling it for 6 hours, the wood is taken out, 3 pounds of copperas are thrown in; and, after continuing the ebullition for 15 or 20 minutes, the copper is taken from the fire. The feathers are then immersed, by handfuls, thoroughly soaked, and worked about; and left in for two or three days. They are next cleansed in a very weak alkaline ley, and soaped three times. When they feel very soft to the touch, they must be rinsed in cold water, and dried. White feathers are very difficult to dye a beautiful black. The acetate of iron is said to answer better than the sulphate, as a mordant.* For dyeing other colors, the feathers should be previously well bleached by the action of the sun and the dew; the end of the tube being cut sharp like a toothpick, and the feathers being planted singly in the grass. After fifteen days' exposure, they are cleared with soap. The following named colors may be produced by means of the coloring substances, &c., given opposite to each:—

1. *Deep red*, by a hot solution of Brazil-wood, after aluming the feathers.
2. *Crimson*.—Give the feathers red as above, and then pass them through a bath of cudbear.

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* See chapter I. Part III., article *Iron*, and chapter IX. of the same Part, article *Processes of Dyeing Black*.

3. *Prune de Monsieur.*—Give deep red, as for red or crimson, as above, and then pass them through an alkaline bath.

4. *Rose color or Pink*, may be given with safflower and lemon juice.

5. *Yellow.*—Alum the feathers and then pass them through turmeric or weld. By a proper mixture of these colors or dyes, of course various other tints may be obtained.

GRAY.—*Of Nut Grays, Thorn Grays, Black, and Iron Grays.* All these colors, except black gray, are produced without aluming. The silk being washed from the soap, beetled, and wrung on the pin. A liquor is now made of (fustet) young fustic, logwood, archil, and copperas. The fustet gives the ground, archil the red, logwood darkens, and the copperas softens all these colors, turns them gray, and at the same time serves instead of alum to extract the several colors. As there is an infinite variety of grays without any positive names and produced by the same methods, it would be endless to enter into a detail that would be to no practical purpose.

Suffice it to remark, that in producing a reddish gray, the archil should predominate: for those more gray, the logwood; and for those still more rusty and rather greenish, fustic. In general, when obliged to complete the color with logwood it should be used rather sparingly, because it is apt, in drying, to darken too much, differing in this particular from all other colors. Grays are also made, as already stated,* by grounding them in a very weak or dilute black dye. The different shades of gray can be given by additions to this ground: thus, for *pearl gray*, a very dilute logwood blue, on the black gray: for *dove*, a very slight tinge of red on the black gray, and so on.

BROWN.—The processes by which the gradations of black are obtained that form the different shades of gray, have been already described.† It has been shown, that dissimilar shades might be blended with them, so as to cause

* See chapters I., II., and IX., Part III., and chapter IV. Part IV.

† See chapter IX. Part III., article *Catechus Brown;* see also chapter IV. Part IV., article *Brown*, and the articles *Camwood, Catechus*, and *Logwood*, chapter III. Part I.

them to incline towards certain colors; but the black is often employed for certain colors which are to remain predominant, and which should be merely browned. At the same time, they become more durable.

BRONZE.—Silk may be dyed a *bronze* color by the union of olive dyes with red. For this purpose, three different baths should be employed; one for logwood, one for Brazil-wood, and one for fustic. The silk, after being boiled with soap, is alumed, and then dyed in a bath compounded of these three decoctions, mixed in the requisite proportions.

CHAPTER II.

VIOLET, PURPLE, GREEN, AND ORANGE.

Processes of Dyeing Violets, Lilacs, Pigeon-necks, Mallows, &c.—Purple, Gilly-flower, Grisdeline, and Peach-blossom—Green—Emerald, Landscape, Willow, Bottle-greens, &c.—Olive—Russet-olive—Aurora, Orange, &c.

VIOLET.—From the mixture of red and blue, are obtained violet, purple, dove-color, amaranth, lilac,* and a great many other shades, determined by the nature of the substances whose red color is combined with the blue color, of which one becomes more or less predominant over the other, according to the proportions of the ingredients, and other circumstances of the process.

Goods dyed scarlet, take, according to the observation of Hellot, an unequal color, when blue is to be united with it. It is proper, therefore, to begin with the blue ground, which, even for violet and purple, should not be deeper than the shade denominated sky-blue. A preparation is given with alum, mixed with two-fifths of tartar; the goods are next passed through a bath composed of nearly two-thirds as much cochineal as for scarlet, to which tartar is always added.†

For fine violet, Berthollet recommends to give the cochineal dye first, and then the blue in the vat. The silk is prepared and receives the cochineal as for crimson,—with this differ-

* *Lilacs, pigeon-necks, mallows, &c.*, are passed usually through the preparation that has served for violet, with the addition of alum and tartar. The blue ground is proportioned to the shade wanted, as well as the quantity of cochineal. For some reddish shades, as peach-blossom, a little solution of tin is added. It may be remarked, that although the quantity of cochineal is diminished when a light shade is wished for, yet the quantity of tartar is not, so that its relative proportion to the cochineal is greater, the lighter the color is to be.

† Violet and purple are often dyed in the spent scarlet bath, by adding the quantities of cochineal and tartar deemed necessary. The operation is conducted in the same manner as for scarlet.

ence, that neither tartar nor solution of tin, which serve to heighten the color, is put into the bath. More or less cochineal is introduced, according to the intensity of the shade wanted.

To give mere strength and beauty to the violet,* it is usually passed through the archil bath; and this practice, frequently abused, is indispensable for the light shades, because the color would otherwise be too dull.

Common or fugitive violets, are given to silk in various ways. The most beautiful, and those most in use, are prepared with archil. The strength of the archil bath is proportioned to the color wished for. Less blue, or less archil, is given, according as the violet is wished to incline to red or to blue.†

PURPLE.—The only difference between the violet and purple dyes, is, that for purple a lighter blue ground is given, and a greater proportion of cochineal is employed. For light shades of purple, cold water is had recourse to into which a little of the blue vat is put, because they would take too much blue in the vat itself, however weak it may be. The light shades of this color, such as pink and peach-blossom,

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* Beautiful violets may be produced on silk by means of a solution of indigo, or chemic; but they have little permanence, and become reddish, because the color of indigo fades first.

† A particular circumstance has led us, says a recent writer (M. Lebaillif) in the *Annales de Chimie*, to discover the coloring property possessed by a solution of mercury in nitric acid, made with a gentle heat, when put in contact with silk at a temperature of from 86° to 164° F. Experiments, says this author, have shown that these substances are capable of giving an amaranth color, more or less deep, to silk. The silk should be entered at a temperature of 112° or 113° F., and worked for ten or fifteen minutes in nitric solution of mercury. It should then be worked, at a temperature of 70° F., in two parts of nitric acid. This solution is afterwards exposed to a boiling heat, in order to convert a part of the proto-nitrate of mercury into deuto-nitrate. To use this solution for the purposes of dyeing, dilute it with its bulk of water, and dip in the silk at the temperature above indicated. In the different operations, says M. Lebaillif, that we have performed, we have given silk a sufficiently permanent *amaranth red color*, which appeared to resist long enough the action of light, *and which is not altered in the cold, either by alkaline solutions, or by sulphuric acid diluted with water.*

are made in the same manner, with a diminution of the proportion of cochineal.*

GREEN.—As the best methods of dyeing green, on cotton and wool, have been described in Parts III. and IV. it is not necessary that we should extend the subject here to any very considerable length, at least, to no greater extent than is necessary to show the application of the color as applied to silk.

As has been already stated, when treating of this color, green is composed of blue and yellow, and is with difficulty produced on silk, because the blue vat is liable to spot, an inconvenience more perceptible in green than in blue. Silk intended for green, is boiled as for ordinary colors; for light shades, however, it should be boiled thoroughly as for blue. Silk is not first dyed blue like woolen cloth or goods; but after a strong aluming, it is washed slightly in the river, and distributed into small hanks, that it may take the dye equally; after which it is turned carefully round the sticks, through a bath of weld. When the ground is sufficiently deep, a pattern is tried in the vat, to see if the color has the wished-for tone; if it has not ground enough, decoction of weld is added; and when it is ascertained that the yellow has reached the proper degree, the silk is withdrawn, and passed through the vat as for blue. To render the color deeper, and at the same time to vary its tone, there are added to the yellow bath, when the weld has been taken out, juice of Brazil-wood, decoction of fustet, and anotta.

There are several shades of green known to dyers: thus a sea green has twenty-five or thirty graduations, from the weakest, called *Pistachio green*, to the darkest, called *Terasse green*. These greens are produced in the following manner:—

1. The silk is first boiled, as usual, then strongly alumed; it is then cooled at the river, and distributed into hanks of about four or five ounces each. This precaution is necessary for giving the yellow ground to all silk intended for green;

* The shade next to purple is *gilly-flower*; then *grisdeline*, then lighter still, *peach-blossom*: all these are made with somewhat smaller proportions of the ingredients, or are made followers to the deeper colors.

because thus distributed in smaller banks, it is more evenly dyed, which is of the greatest consequence.

2. The weld is now boiled, and a portion of the liquor is mixed with clean water, strong enough to give a good lemon ground. The silk should then be carefully turned in this liquor, from hand to hand. When the ground seems nearly full enough, some threads of the silk are dipped in the blue vat to try whether the color of the ground is sufficiently full for the shade required; if not, add a little weld decoction. When the color comes out good, the silk is cooled and beetled once; then wrung and formed into hanks convenient for dipping in the vat. Dip skien by skien as for blues, it is wrung quickly and with the precautions above noticed.

3. All the lighter shades, fifteen or sixteen in number, of this green, only require to be dipped in the vat to be completely finished.

4. As to the Pistachio green, if the vat be yet too strong, the silk should be taken out, and carefully opened and aired, but not washed. It is then worked in the hands, that is, held in one hand and struck with the other, by which means the silk being disentangled and aired, the color becomes equally clear. A few threads are then rinsed, and if the color is right the whole is washed, which finishes the operation.

5. Dark shades may be produced when the weld is exhausted, by adding a little logwood liquor to the bath; and for the darkest, a decoction of fustic will produce the desired effect. After which the silk should be washed and beetled. It should then be dipped in the vat; always remembering that the perfection of the color depends upon washing and drying quickly when it comes out of the vat.*

Emerald or Meadow Green.—The only difference between the meadow and the emerald green is, that the first is rather the darkest. Emerald green is alumed as for sea green; after having cooled and rinsed the silk at the river, it is dipped and worked in the weld liquor that had been previously used for a sea green. When the color seems even, some threads are put into the vat to try the effect of the ground: if the green be too blue, it is again put into the decoction of the weld, or a fresh one. The vat is then stirred, and the silk again entered, till by making a fresh essay the ground for the shade required is obtained.

For *landscape greens*, a mixture is necessary to give them something of a red tint in addition to the yellow and blue.

* There are many other shades, differing from the sea green, because they have a yellow cast: they are, however, produced by the same ingredients. for example, the *willow green*. These greens when alumed are dipped in a very strong weld liquor, and when exhausted, fustic or annotta are added to complete the shade. If the color requires darkening, a little logwood may be given after the fustic or anotta. The silk is afterwards dipped in the vat.

This is done by mixing a small quantity of Brazil with the weld liquor, when giving the yellow.

Mixed greens, says Berthollet, that require brazil, or fustet, should receive the color of these drugs, either on the weld yellow, or previous to welding. For when once the silk has entered the indigo vat, it is unalumed; nor can it then take any other color but black, which stripes without any additional mordant; or else by means of logwood and copperas. These two colors are always given upon a blue ground, but no other.

Bottle Green.—There are a great many shades of this color, but they are all managed pretty much in the same way, as the foregoing. The silk must be well alumed; then washed, and dyed in weld liquor.

Thus it will be perceived, that all greens which are made simply from the combination of yellow and blue, are produced in pretty much the same way, at least the difference in the processes of varying the shades is but slight, and depends entirely upon the skill of the dyer.

OLIVE.—The mixture of red and yellow requires no peculiar observations, in addition to what has been already stated in the preceding sections of this work.

Russet olive.—This color may be obtained, by giving fustet and logwood liquor after the welding, without alkali. If a more reddish color be required, the fustet should be omitted, and the logwood given (after the welding).

In all these matters, however, some experience is necessary, as has been already shown; good taste, it should ever be remembered, is an indispensable qualification, and without which no dyer ever has or ever will become eminent in this or any other branch of manufacturing industry. It should also be borne in mind, that a dyer, to become eminent, must possess *a thorough knowledge of the elements of chemistry;* for it is absurd to talk of a dyer who is ignorant of chemical science; every step he takes must be in the dark.*

* See chapter II. Part I., and chapter II. Part III., article *Purity of Water*, where we have given some practical instructions on the qualifications necessary for a good dyer.

AURORA AND ORANGE.—For silks intended to become aurora and orange, it is sufficient to scour them at the rate of 20 per cent. of soap. Then dye with anotta, more or less, according to the shade required.*

"When raw silks," says Berthollet, "are to be dyed, those naturally white are chosen, and dyed in the anotta bath, which should be cold, in order that the alkali may not attack the gum of the silk, and deprive it of the elasticity which it is desirable for it to preserve."

"To make," says another writer, "an orange hue, which contains more red than the aurora, it is requisite after dyeing with anotta, to redden the silks with vinegar, alum, or lemon juice. The acid, by saturating the alkali employed for dissolving the anotta, destroys the shade of yellow that the alkali had given, and restores it to its natural color, which inclines a good deal to red." For the deep shades, the practice at Paris, as Macquer informs us, is to pass the silks through alum; and if the color be not red enough, they are passed through a faint bath of Brazil-wood. At Lyons, the dyers who use safflower, sometimes employ old baths of this ingredient for dipping the deep oranges.

Guliche recommends to avoid heat in the preparation of anotta. In this he is perfectly right, as we have shown in chapter VI., Part III., article *Orange with Anotta.*

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* See next chapter (III.), article *Pinks, Crimsons, Roses, &c. with safflower;* see also chapter III. Part III., article *Safflower Pink;* and chapters V. and VI. of the same Part (III.), articles *Safflower and Prussian Blue,* and *Orange with Anotta.*

CHAPTER III.

OF BLUE, YELLOW, SCARLET, CRIMSON, &c.

PROCESSES OF DYEING BLUE ON SILK.

Processes of Dyeing Blue with Berries—With the Indigo Vat—With Chemic, or Solution of Indigo—Yellow with Chrome—With the Sulphuret of Cadmium—With Weld—Scarlet—Flesh-color—Crimson—Violets—Puces—Crimsons with Brazil-wood—Pinks, Roses, &c.—Safflower, Beautiful Process of Dyeing with, which supersedes every other method—Cherry Reds—Rose-Colors, &c.

We shall commence this subject by referring the reader to chapter IV., Part I., and also to chapter V., Part III., articles *Chemistry of the Blue Vat*, *Preparation of Chemic*, *Sulphate of Iron*, *The Common Blue Vat*, *Prussiate of Potash*, *Processes of Dyeing Prussian Blue*, and *Safflower and Prussian Blue;* in all of which, we hope, very valuable, as well as new information has been given upon these subjects.

I. DYEING BLUE WITH BERRIES, &c.—The materials employed for this purpose, are indigo, Prussian blue, logwood,* bilberry, elder berries, mulberries, privet berries, and some other berries whose juice becomes blue by the addition of a small portion of alkali, or of the salts of copper.

To dye blue with such berries as the above, boil one pound of them in water, adding one ounce of alum, one of copperas, and one of blue vitriol, to the decoction, or in their stead equal parts of verdigris and tartar, and pass the goods for a sufficient time through the liquor. When an iron mordant alone is employed, a steel blue tint is obtained; and when a tin one, a blue with a violet cast.

With alkalies and acids, the privet berries have the same habitudes as bilberries, the former turning them green, the latter red. They usually come from Italy compressed in dry cakes, and are infused in hot water. The infusion is

* See chapter III., Part I., article *Logwood*.

merely filtered, and then employed without any mordant, for dyeing silk, being kept at a warm temperature by surrounding the bath with hot water. The process is as follows:—

The goods must be reeled for six hours through the bath, in order to become thoroughly saturated with the color; they are then to be rinsed in running water, and dried.

One pound of silk requires a pound and a half of the berry cake. In the residuary bath, other tints of blue may be given. Sometimes the dyed silk is finished by running it through weak alum water.

A color approaching to indigo in permanence, but which differs from it in being soluble in alkalies, though incapable of similar disoxidizement, is the *gardenia genipa* and *aculeata* of South America, whose colorless juice becomes dark blue with contact of air; and dyes stuffs, the skin, and nails, of an unchangeable deep blue color, but the juice must be applied in the colorless state.

II. INDIGO BLUE.—The first observation to be made is, that the raw silk should be previously boiled in soap and water, thirty pounds to the hundred weight; and that by scrupulous washing and beetling, every part of the silk should be perfectly freed from soap; for soap, as already observed, spoils the indigo vat, and occasions the goods to be spotted. The vats are conical such as are commonly used for the blue dye of woolen, and mounted in the same manner. There should be three vats of different degrees of strength, and size; a vat of ten buckets to be charged with a pound of indigo, one of twelve buckets to be charged with three pounds, and one of fifteen buckets to be charged with six pounds. The first and smallest vat should be kept weak; it can be strengthened, when necessary, by means of the third.

The management of the vat is much the same as in dyeing wool, which see. The vats are charged exactly as for woolen goods. When the silk is entered into the vat, it should be done by a hank at a time, of not more at the utmost than eight or ten ounces weight; it should be worked on a stick under the liquor, and after being turned four or five times, taken out to air, that it may acquire the blue: this

will not take more than half a minute or less; it should then be dipped again and worked in the liquor until it has acquired the color wanted. When the first hank is worked in the liquor, observe how many turns it receives in the dye, and how often it is taken out to air, and give exactly the same number of turns to each succeeding hank, else the color will be deeper on some hanks than on others in the same parcel.

As already observed, silk dyed blue in the vat, should be wrung well and expeditiously with the hand; neither should it be permitted to turn blue in the air, but should be carried to the water and washed immediately. For this purpose, there should be two tubs of water, so that after washing in the first tub it may be more thoroughly cleansed in the other. If there should be a dry wind or current of air, the silk will not be dyed evenly, if it is not wrung dry quickly (or taken to a room well heated, in which there is a swing ventilator, which must be kept in motion till the silk has acquired the blue color,) it will spot. Indeed, all silk dyed blue should be dried in ten minutes; and should be shaken and kept in constant motion while airing: otherwise it will turn blue unevenly or in streaks.

It is for this reason that on taking it out of the vat, it is necessary to plunge it into water to take off the green color; the air in the water answering this purpose: a little sulphuric acid would ensure and expedite this use of the water.

It should, however, be remarked, that no deep blue can be given to silk by the indigo vat alone. The silk, therefore, must first receive a strong grounding with archil, before entering in the vat. It is necessary also, from time to time, to try the strength of the vat, to know the depth of the archil color that must previously be given; and when the archil ground has been given, the silk must be washed and well beetled before dyeing the blue.

For the dyeing operations, with the blue vat, four persons are necessary; one dyes and washes the silk; another wrings it carefully; a third opens it; a fourth moves the swing fan while the silk is being dried. When the hanks are opened, the strings should be cut, that the air may have

access to every part. For dyeing silk, particularly with the blue vat, fine dry weather should be chosen.

In dipping silk which is intended for various shades, that meant for the darkest should be dyed in the freshest or strongest vat, and so on continuing to dip in the same manner; except that as the vat weakens, or becomes exhausted, the silk should be left in a little longer each time.* When the vat has greatly decreased in strength, it will answer for the lighter shades. After dyeing a considerable quantity of goods, the vat is apt to lose its green color, in which case it is necessary to refresh it with pearlash, madder, and bran, in the original proportions, about a fourth part of the first dose; observing, however, that these new ingredients should be boiled together for a few minutes before they are put into the vat, which should then be well raked up, covered, and suffered to rest for a few hours before using it.

All these directions are necessary, as well as dexterity in the handling.

III. CHEMIC BLUE.—Dyeing silk blue with chemic or sulphate of indigo, differs but little from the processes already described for dyeing wool.†

For English blue, says Berthollet, a light blue must be first given to the silk in the vat. On being taken out, it is passed through hot water, washed in running water, and put into a bath composed of the sulphuric solution of indigo (chemic,) to which a little solution of tin has been added, till it has assumed the desired shade, or has exhausted the bath. Before introducing the silk into this bath, it may be passed through a solution of alum, in which it must not be suffered to remain long.

Silk dyed by this process, says this author, has neither the reddish cast of the indigo vat, nor the greenish cast of the blues dyed with chemic.

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* As raw silk takes a deeper color than boiled silk, therefore, the boiled silk should be dyed first.

† See chapter III. Part I., article *Indigo;* see also chapters V. and VII. Part III., articles *Preparation of Chemic*, and *Common Blue Vat;* and chapter III Part IV.

IV. PRUSSIAN BLUE.—The application of mineral coloring substances to cotton, silk, &c., is one of the most marked improvements in modern dyeing. As long ago as the year 1811, Mr. Raymond received from the French government the sum of 8,000 francs, as a reward for communicating to the public his process for dyeing *silk* of a uniform, fast, and bright Prussian blue color. To obtain the color he proceeds as follows :—

1. By a gentle calcination till sulphurous acid fumes begin to appear, he converts copperas into the red sulphate of iron. This he dissolves in sixteen times its weight of warm water, and filters, when he has a clear solution of a lively yellow color, bordering on red.

2. The silk, prepared as for the indigo dye, is put into this solution, and left there a shorter or longer time, according to the shade of blue that is wanted; then taken out, and well wrung.

3. The silk is now thoroughly cleaned at the river, by beetling twice: plunging and agitating each time.

4. Dissolve in pure water (heated to 167° F.) one ounce of ferroprussiate of potash to every twelve ounces of silk.* When the prussiate is entirely dissolved, add one part muriatic acid, at about 21° Baume, stirring well, and when the liquor has assumed a greenish cast, the silk must be immediately plunged in and stirred about for a few minutes.

5. The silk having received the blue equally is taken out, wrung and beetled two or three times: plunging and agitating each time, to free it from any loose portions of the prussiate.

6. Should the prussiate bath become of a blue color when the silk is dipped in it, it is an indication that it contains either too much prussiate or muriatic acid, or that the silk, after passing through the mordant, had not been sufficiently cleaned. Now take out, wash well at the river, wring tightly with the hands, and place loosely on poles.

7. Fill a large vessel, three-fourths full, with cold water, and add, to every 100 pounds of silk, two pounds of ammonia (water of), marking 21° of Baume's spirit hydrometer. The blue will immediately become, at least, three shades deeper: taking a much richer and brighter tint, at the same time fixing more perfectly in the silk. The change is effected in a few minutes. Wring out, and rinse in running water, without beetling; then dry on poles, like other dyed silks.†

The solution of a little soap, added cold to the ammonia bath improves the color and softens the silk: making it easier to separate. The soap must be perfectly dissolved before

* 144° F. is, according to Mr. Raymond, the most suitable temperature for the prussiate bath.

† The silk need not be left on the poles over twenty hours to give the color time to come out well.

adding it.—(See chapter V. Part III., article *Prussiate of Potash.*)

V. YELLOW WITH WELD.—The raw silk should be boiled with twenty-five pounds of soap to every hundred pounds of goods. Then washed, beetled, and alumed in the usual way; after aluming, wash, place on rods, in hanks of half a pound each. Now dye (at 120° F.) with two pounds of weld to the pound of goods.

Some dyers use a small quantity of pearlash with the weld, which, they say, brightens the color and aids the aluming, by suddenly fixing it on the goods, before any of the alum is dissolved (from the goods) in the bath. The silk is worked in the weld liquor till the proper shade be obtained.

Quercitron may be substituted for weld. The color may be brightened by adding a little chalk or potash towards the end of the operation. The solution of tin may also be used.*

For *pale lemon* and *canary* colors the silk is scoured as for blue. The strength of the bath is proportioned to the shade sought for. If it be wished to have a yellow cast verging on green, more or less of the indigo vat is added, if the silk has been scoured without azuring.†

To prevent these shades from being too deep, a slighter aluming than usual may be given to the silk.

VI. YELLOW WITH CHROME.—Cleanse the silk at one heating of two hours, wash and wring; plunge the skeins in a solution, more or less strong, of subacetate of lead,‡ according to the depth of yellow sought for. At the end of two hours, take out the goods, and expose to the air for half an hour; wash, and wring.

Now prepare a bath, in which a sufficient quantity of neutral chromate of potash (about from the fifteenth to the twenty-eighth part of the weight of the silk) is dissolved. Neutralize the bath with half a glassful of muriatic acid; then enter the goods for half an hour, at nearly boiling heat. They are now taken out, and wrung upon poles, over the bath;

* See chapter I. Part III., article *Tin.* † See chapter III. Part II.
‡ See chapter I. Part III., and Appendix, article *Acetate of Lead.*

after which they are washed in a slight solution of soap, at a lukewarm heat; then in a stream of cold water.

The shades may be varied by giving more or less of the subacetate of lead, and chromate of potash, which must always be neutralized by muriatic acid.—(See chapter IV. Part III., article *Processes of Dyeing Yellow*, and chapter VII. of the same Part, article *Processes of Dyeing Orange.*)

VII. GOLDEN YELLOW BY SULPHURET OF CADMIUM.—We have already shown the application to the dyeing of tissues, of several mineral compounds, remarkable for a lively and durable color, as well as for their unalterability on exposure to light. Among these may be mentioned, Prussian blue, orpiment, and chromate of lead.

The sulphuret of cadmium may be fixed on silk, by first impregnating the goods with chloride of cadmium, and afterwards passing them through a weak solution of hydro-sulphate of potash or soda. It is easy to perform this operation, which is simply,

Keeping the silk immersed in a solution of chloride of cadmium, at a temperature of from 120° to 140° F., during fifteen or twenty minutes; wringing out, and then passing it, at a common temperature, through a dilute solution of hydro-sulphate of potash in water. As soon as the silk is immersed in this solution it takes a golden yellow tint, and which remains intimately combined with the substance of the silk.

The facility with which silk may be dyed by the process above mentioned, leads us to believe that if cadmium was to become more common, its sulphuret would be employed in painting as well as in dyeing. Indeed, the giving of color to textures, by this new mineral compound, would obviate inconveniences which are naturally attached to the yellow dyes by sulphuret of arsenic (orpiment,) and chromate of lead.

If the results here presented can find no direct application at this moment, we shall have at least fixed the attention of chemists and practical dyers upon the subject, which is our principal aim in giving the foregoing article.

VIII. SCARLET.*—Bancroft states that if the tartar be left out the color will be a crimson; that the tartar gives rise

* See chapter I., Part IV.

to an insoluble tartrate of tin, which forms with cochineal a yellow color; that the ordinary scarlet is a mixture of one-fourth of this yellow color, and three-fourths, or a little more of the crimson color, which cochineal gives with the solution of tin. Consequently, he proposes to substitute for the tartar, a preliminary dye with quercitron, which, by its yellow, produces the same effect, and to dye afterwards with solution of tin and cochineal, of which, in this case, no more than four-fifths of the ordinary proportion are required. We have dyed, says Berthollet, scarlet, by employing these proportions of solutions of tin and tartar; in another pattern, we doubled the proportions of tartar; and in a third, we left out this ingredient. The first took a beautiful scarlet; the second inclined more to yellow; and the third had a vinous cast, and was less lively, although not exactly crimson. It is true, therefore, that the tartar causes the color of cochineal to incline to yellow, and that it produces more of this effect, the greater its proportion.

If the proportion of the solution of tin is too great, it becomes prejudicial, *and impoverishes the color*, because a portion of the coloring matter is retained in solution. It may also be remarked, as a general rule, *that the larger the proportion of tin the deeper the color*. We have been sufficiently diffuse upon this subject in chapter I., Part IV.*

IX. CRIMSON.—Silks intended to be dyed cochineal crimson, according to Macquer, should have only 20 pounds of soap to 100 pounds of silk.

1. When boiled, washed, and beetled, the silk is soaked in

* *Flesh color* is made in the sequel of the finishing bath of the scarlet dye, by throwing away a little of the bath, and refreshing it with cold water. The boiling must continue but for a very short time. Flesh color may likewise be made in the sequel of the violets, by adding a little solution of tin. It must, however, be observed, that the weak and delicate shades of *oranges, lilacs, mallows, cherries, and roses*, have more lustre and freshness when dyed in a single bath, than when they are subjected to both the preparation and finishing baths. On this account it is sufficient to introduce into this bath the necessary ingredients. The cloth, when merely moistened and unimpregnated with mordant, becomes charged with the coloring particles less readily, but in a more even manner. There is also in this mode of operating a saving of time and fuel.

a strong alum water from 12 to 15 hours; then washed at the river sufficiently to rid it of superfluous alum, but no more; although some recommend to wash several times and beetle twice; but this only serves to wash away the alum.

2. The bath is now filled to within six inches of the top with cold water. Bring to a boil: cool down with a little cold water; then throw in from one to two ounces white galls,* and from two and a half to three ounces of cochineal to each pound of silk.† Let boil for three quarters of an hour; then add one ounce of scarlet compostion for each pound of cochineal. This compostion is made in the following manner:—

Dissolve 2 ounces of sal ammoniac, in 12 ounces of water; add this to 1 pound of aquafortis (nitric acid), and give six ounces of feathered tin.

3. The bath is now cooled down with a little water, and the silk immediately entered; turning the skeins or hanks round the sticks till they appear of a uniform color. The fire is then increased, and the bath kept boiling for two hours, turning round the silk from time to time; after which the fire is withdrawn, that is, after the expiration of two hours. The silk is now left in the bath for some hours; then washed in the river, giving two beetlings, when it is wrung and dried.‡

The color may be saddened, if desirable, with copperas, according to the shade required. The copperas deprives the cochineal of its yellow color, and gives it a violet hue. Nothing, says Mr. Cooper, but copperas, is fit to sadden cochineal scarlets, which it does by means, chiefly, of the galls employed in the dye.

X. GENOA CRIMSON.—The boiling process is precisely

* White galls are preferable, because black ones deaden the crimson; and if even too large a quantity of the former be introduced, the color becomes duller. Macquer says that the galls serve merely to increase the weight of the silk; their general effect, however, is to render the colors more durable. They are indispensable at least for the crimsons intended to be saddened or browned.

† It is seldom necessary to use quite three ounces of cochineal to the pound of silk.

‡ It is customary, indeed, it is necessary, before entering the goods in the dye-liquor, to dip them in lukewarm water. This makes the dye strike evenly.

the same as already described, namely, at the rate of 20 pounds of soap to 100 pounds of silk.* The process of dyeing the color, for 72 pounds of silk, is as follows:—

1. From 16 to 18 pounds of finely powdered roach alum is thrown into a copper full of cold water,† and as soon as the alum is perfectly dissolved the silk is entered, where it should remain, if for a deep color, from 12 to 15 hours. It is then taken out and washed at the river, as much as is necessary to clear away the crystalized alum; more than this, as already observed, is injurious. After the washing, the hanks should be dressed on the skein sticks, that they may take the dye equally.

2. Of the 72 pounds of silk, above mentioned, 39 pounds are organzine or warp: the remainder weft. At Genoa, it is customary to allow 2 ounces of cochineal to 12 ounces of organzine, if intended for the warp of damask furniture, and one and three quarter ounces to 12 ounces of the weft; supposing it necessary to the beauty of the color, that the warp should be something fuller than the weft; then they add 2¼ ounces of cochineal instead of 2 ounces, as above stated. They do not, however, give any additional quantity to the weft.

3. To dye this quantity (72 lbs.) of silk, they make use of an oval copper, containing, when full, 200 quarts of water. The copper is filled with soft water, and into which 2 ounces of tartar, 2 ounces of safflower, and 2½ pounds of well mashed white galls are put. After these drugs have boiled for 15 minutes, 11 pounds 10 ounces of cochineal is added. The silk is now entered as usual; but the organzine is left a quarter of an hour longer in the liquor than the weft, which gives it a deeper color. One hour and three quarters is sufficient for the weft, and two hours for the warp.

The Genoese are persuaded that the water, both for dyeing this color, and the washing afterwards, should be the finest spring water; for they remark, that the crimson dyed in summer with cistern water, is by no means so bright as the crimsons dyed at other seasons when the fountains are full.—(See chapter II. Part III. article *Purity of Water*.)

XI. DYEING WITH BRAZIL-WOOD.—The use of Brazil-wood for dyeing what is called *false crimson* is considerable. The silk should be boiled at the rate of 20 parts of soap per cent., and then alumed. The aluming need not

* For scarlet the Genoese use from 45 to 50 pounds of soap to 100 pounds of goods.—(See *Bleaching*, chapter III. Part II.)

† Silk should always be alumed cold: if alumed in warm liquor, it is apt to lose its lustre. It is better to make the alum liquor strong than weak; the alum combines with the silk in this case more evenly and surely. After aluming, the silk must be sufficiently washed to prevent any crystalized alum sticking to it, but no more.

be so strong as for cochineal crimson. The silk is refreshed at the river and passed through a bath more or less charged with Brazil juice, according to the shade required.

XII. PINKS, CRIMSONS, ROSES, &c., WITH SAFFLOWER.—Safflower contains two coloring substances. The one is a yellow, very soluble in water, and of no use to the dyer. To free the safflower from this yellow coloring substance, is a particular part of the manipulation of this dye-stuff. The other coloring substance is red, and is extracted from the vegetable after the yellow substance has been washed away, by means of alkaline carbonates. The substance is used very extensively for dyeing the various shades of *pinks*, *crimsons*, *roses*, &c., upon silk, and also for the same colors upon cotton, with *lavender*, *lilac*, *pearl*. The mode of preparing safflower* for the purpose of extracting the red matter from it, was for a long time that recommended by Berthollet, and followed by all other writers upon the subject; namely, *putting a quantity into a fine bag, "tramping" it with the feet in water until the yellow color was dissolved, and washed away; the mass left was then treated with an alkali to extract the red matter.* But although this red coloring matter is considered insoluble in water, it will be found that the bag in which it is tramped, becomes a deep crimson red, which can only be produced by the partial solubility of this red matter. This, however, appears to be promoted by a peculiar influence exerted by the cloth on the matter in contact with it, as we have never been able to discover any real coloring matter in the water which passed through. Whatever be the cause, there is experienced a considerable loss. To avoid this, the safflower is put into a tub without any bag, with as much water as will cause the whole to float freely. A very little tramping will be sufficient to reduce the cakes to a soft flocculent mass, which is the sole use of tramping. We may remark, that if a piece of cloth be put in amongst the safflower while tramping, it be-

* See chapter III. Part III., article *Safflower Pink*, and chapter V. of the same Part, article *Safflower and Prussian Blue*.

comes red; but if steeped in the water which is expressed from the safflower after being trampled, it does not turn red. The safflower, after being tramped, is removed to a tub or cask, having a false bottom with a plug in it, and covered with fine haircloth. The vessel is filled with clean water, and let out by the plug at the bottom; filled again, and so on, until the water passing through it is not colored yellow. After this it is put into a measured quantity of pure water—*about three gallons to the pound of safflower*—in which is dissolved a little carbonate of soda, or carbonate of potash, (pearl ash does well,) *about an ounce to the pound of safflower*. Some kinds require less than others; but care should be taken that too much is not used, as it destroys the brightness of the color. This being well mixed with the water, is put into the tub containing the safflower; then being well stirred and allowed to stand for about 7 hours, the plug is taken out and the clear liquor drawn into a proper vessel. This liquor contains the red dye which has been extracted by the alkali. The remaining safflower is afterwards washed by pouring upon it a little more water made slightly alkaline; but if fine light colors are to be dyed directly from the solution, this second extract does not answer so well, the shade is not so pure. The liquor extracted in this manner contains both red and yellow coloring matter. For this reason silk goods are not dyed directly by this extract, as the silk takes up a portion of the yellow which renders the color more of a flesh hue than is due in the rose and pink. To dye the silks, proceed in the following manner:—

1. Any old cotton yarn is dyed first by the safflower extract; the cotton yarn takes up nothing but the red.

2. This cotton is then thoroughly washed in cold water till the water coming from it is perfectly clear; it is then steeped for a short time in water made slightly alkaline by carbonate of soda or potash, which extracts the red from the cotton, and forms the dyeing solution for silk.

3. The silk to be dyed pink, generally receives a *bottom* or *ground* by passing it through a weak solution of cudbear or archil, so as to form a flesh white or light lavender—the depth being regulated according to the shade of pink wanted.

4. The silk is then put through the safflower solution, which must previously be rendered acid by a little *lemon-juice vinegar*, or sulphuric acid.* When the

* Of all the acids for this purpose lemon juice is the best.

safflower liquor is exhausted, the silk is washed in clean cold water, and finished by passing through a little water made acid by lemon juice or tartar. Neither vinegar nor sulphuric acid should be used in the finishing process.

Cherry reds, *Rose colors* of all shades, as well as *flesh colors*, are obtained in the weaker solutions of the safflower. The deepest shades should be dyed first. The lightest of all the shades which may be obtained in this manner, is an extremely delicate *flesh color*, and requires a little soap to be put into the bath. The soap, according to Berthollet, lightens the color and prevents it from taking too speedily, or becoming uneven.

CHAPTER IV.

SCOURING OR RENOVATING ARTICLES OF DRESS, &c.

Nature of Scouring Operations—Chemical knowledge indispensable to the Scourer—Should be a Practical Dyer—Simple Stains—Compound Stains—Nature of Stains and the best methods of removing them—Bleaching and removing Stains from Books—Removing Grease, &c., from cloth—Allaire's patent process.

THE art of cleansing clothes being founded upon the knowledge of solvents, the practitioner of it should, as we shall presently illustrate by examples, be acquainted with the laws of chemical affinity. Indeed, the scourer should be a practical dyer, because he is often obliged to combine dyeing with scouring operations. The scourer cleans, re-dyes, and turns out as new, the old garments sent to him, whether of cloth, cotton, linen, gauzes, or silk; but in this art, as in many others, the means that will answer in skilful hands, will only spoil the articles if used by the unskilful.

The art of cleaning cloth, says Chaptal, presupposes first, a knowledge of the various substances liable to occasion spots upon them; secondly, a knowledge of the substances to which we must have recourse in order to remove the spots produced upon the cloth; thirdly, a knowledge of the manner in which the colors of the cloth will be affected by the re-agents meant to be employed for the removal of the spots; fourthly, a knowledge of the manner in which the cloths themselves will be affected by the substances proposed to be employed; fifthly, he should know how to restore the color of the cloth, when rendered faint by the process of taking out the spots.

Among the spots which alter the colors fixed upon cloth, some are caused by a substance which may be described as *simple*, in common language; and others by a substance

which results from the combination of two or more bodies, that may act separately or together upon the cloth, and which may therefore be called *compound*. Oils and fats are the substances which form the greater part of simple stains. They give a deep shade to the ground of the cloth; they continue to spread for several days; they attract the dust and retain it so strongly, that it is not removeable by the brush; and eventually render the stain lighter colored upon a dark ground, and of a disagreeable gray tint upon a pale or light ground. The general principle of cleansing all spots, consists in applying to them a substance which shall have a stronger affinity for the matter composing them, than it has for the cloth, and which shall render them soluble in some liquid menstruum, such as water, spirits, naptha, oil of turpentine, &c.

Alkalies would seem to be proper in this point of view, as they are the most powerful solvents of grease; but they act too strongly upon silk and wool, to be safely applicable in removing stains.* The best substances for this purpose are the following:—

1. Soap. 2. Chalk, fuller's earth, soap stone or steatite (called French chalk). These should be merely diffused through a little water, made into a thin paste, spread upon the stain, and allowed to dry. The spot requires now to be merely brushed. 3. Ox-gall and yolk of egg have the property of dissolving fatty bodies without affecting perceptibly the colors or texture of cloth, and may therefore be employed with advantage. The ox-gall should be purified to prevent its greenish tint from degrading the brilliancy of dyed goods, or the purity of white.

Thus prepared, it is the most precious of all substances known for removing these kinds of stains. The volatile oil of turpentine will take out only recent stains; for which purpose it should be previously purified by distillation over

* The colors of the cloth are often injured by the re-agents made use of. In order to restore them, the operator must, as already observed, thoroughly understand the art of dyeing, and know how to modify the means according to the circumstances. This is sometimes difficult, because it is necessary to produce a color similar to that of the rest of the cloth, and to apply that color to a particular part only. Sometimes also the mordant which fixed the color, or the basis which heightened it, has also been destroyed and must be restored. It is, therefore, evident that the means employed to restore the color, must depend upon the nature of the color, and the means employed to produce it.

quicklime. Wax, rosin, turpentine, pitch, and all resinous bodies in general, form stains of greater or less adhesion, which may be dissolved out by pure alcohol. The juices of fruits, and the juices of all vegetables in general, deposit upon cloths marks in their peculiar hues. Stains of wine, mulberries, black currants, morellos, liquors, yield only to soaping with the hand, followed by fumigation with sulphurous acid; but the latter process is inadmissible with certain colored stuffs. Iron mould or rust stains may be taken out almost instantaneously with a strong solution of oxalic acid. If the stain is recent, cream of tartar will remove it.* The mixture of rust of iron and grease forming *compound spots* or stains, is an example of this kind, and requires two distinct operations; first the removal of the grease, and then of the rust, by the means above indicated. Mud, especially that of cities, is a compound of vegetable remains, and of ferruginous matter in a state of black oxide. Washing with pure water, followed, if necessary, with soaping, will take away the vegetable juices; and then the iron may be removed with cream of tartar, which itself must, however, be well washed out. Ink-stains, when recent, may be taken out by washing, first with pure water, next with soapy water, and lastly with lemon juice; but if old, they must be treated with oxalic acid.† Stains occasioned by smoke, or by sauces browned in a frying pan, may be supposed to consist of a mixture of pitch, black

* *Undiluted* muriatic acid will also remove iron mould or rust stains, ink spots, &c., but immediate and thorough washing is necessary after the acid has been applied. The spots or stains will be removed by the acid in about half a minute. If the acid is diluted it will rot the goods, and fail in effecting the purpose. With the pure acid, however, and thorough washing, the finest muslin will not be injured.

† The clear solution of chloride of lime, diluted with twice its bulk of water, will effectually and expeditiously remove stains from prints and printed paper. Instead of the ordinary process which is expensive and tedious, first soak the print in clear water, till it lies smooth; then remove it into a dish, large enough to hold it flat, filled with the solution diluted as above—the stains will disappear in a few minutes, soak again in clear water, to free it from the chloride of lime, and dry it between sheets of blotting-paper. By this process we have bleached twelve prints, and letter-press belonging to an expensive book, which had been damaged by rain and sea water.

oxide of iron, empyreumatic oil, and some alkaline matters dissolved in pyroligneous acid, and even the empyreumatic oils in a great measure; the essence of turpentine will remove the rest of the oils and all the pitchy matter; then oxalic acid may be used to discharge the iron. Coffee stains require a washing with water, with a careful soaping, at the temperature of 120 F., followed by sulphuration. The two latter processes may be repeated two or three times. Chocolate stains may be removed by the same means, and more easily.

As to those stains which change the color of the cloth, they must be corrected by appropriate chemical re-agents or dyes. When black or brown cloth is reddened by an acid, the stain is best counteracted by the application of water of ammonia. If delicate silk colors are injured by soapy or alkaline matters, the stains must be treated with colorless vinegar of moderate force.* An earthy compound for removing grease spots is made as follows:—

Take fullers'-earth, free it from all gritty matter by elutriation with water; mix with half a pound of the earth so prepared, half a pound of soda, as much soap, and eight yolks of eggs well beat up with half a pound of purified ox-gall. The whole must be carefully triturated upon a porphyry slab; the soda with the soap in the same manner as colors are ground, mixing in gradually the eggs and the ox-gall previously beat together. Incorporate next the soft earth by slow degrees, till a uniform thick paste be formed, which should be made into balls or cakes of a convenient size and laid out to dry.

A little of this detergent being scraped off with a knife, made into a paste with water, and applied to the stain will remove it. Purified ox-gall is to be diffused through its own bulk of water, applied to the spots, rubbed well into them with the hands till they disappear, after which the cloth is washed with soft water. It is the best substance for removing stains on woolen cloths.† The re-distilled oil of turpentine

* Lemon juice is used to brighten scarlet cloth, after the spots or stains have been removed.

† A writer in the *London Mechanic's Magazine*, gives the following method of cleansing cloth from *grease*:—"This process consists in washing the cloth in warm water to deprive it of paste or gum, then to impregnate it with a mixture

may also be rubbed upon the dry cloths with a sponge or a tuft of cotton, till the spot disappears; but it must be immediately afterwards covered with some plastic clay reduced to powder. Without this precaution a cloud would be formed round the stain, as large as the part moistened with the turpentine. Oxalic acid may be applied in powder upon the spot previously moistened with water, well rubbed on, and then washed off with pure water. Sulphurous acid is best generated at the moment of using it. If the cloths be much stained, they should be suspended in an ordinary fumigating chamber (such as is described in chapter V., Part II). For trifling stains, the sulphur may be burned under the wide end of a small card or paper funnel, whose upper orifice is applied near the cloth.*

Mr. René Allaire, of Charlotte street, Fitzroy-square, London, dyer and cleaner, obtained a patent, in April, 1844, for "improvements in cleansing gentlemen's garments." The object of the invention is the use of certain apparatus for applying the heat of steam for cleansing gentlemen's garments, and removing grease, tar, or oil spots; and also for drying garments which have been cleaned by washing.

The apparatus consists of hollow shapes, suitable for receiving the garments upon them, and made steam tight. These shapes, on steam being admitted into them, will not only dry a washed and wet garment, but, at the same time, any grease or oil spots will be removed; the surface of the fabric is then brushed, and, if desired, the nap may be slightly improved with soft sharp wire cards.

Fig. 21, is a back view, and fig. 22, a vertical section of a hollow shape for a coat. The arm, *a*, is moveable, and is first introduced into one sleeve of the coat, after which the coat is placed on the hollow shape, and the arm is fastened in

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of fullers'-earth, potash, or other alkaline material, and, thus prepared, to suspend it in a tight box or receiver and subject it to the action of a jet of steam. When withdrawn, it is thrown into the water and passed between two cylinders to clean it. The cloth, in this process, receives no fulling, and by means of a small boiler, which costs but little, a large amount of work can be rapidly performed."

* See *Bleaching*, chapters I., II., III., IV. and V., Part II.

Fig. 21.

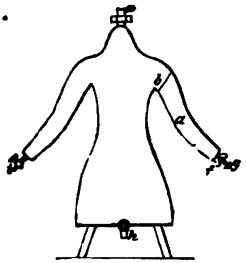

Fig. 22.

its place by the means represented in the enlarged sectional view, fig. 23. In the upper end of the arm, *a*, is a groove, furnished with suitable packing, to receive the end of the stump *b*; the arm and stump are secured together by a rod, *c*, with an oblong head, which is passed through suitable openings in the bars, *d*, *e*, (fixed in the end of the arm and stump,) and turned partly round, to prevent the return of the head; the rod, *c*, is then firmly retained in its position, by screwing up the nut, *f*, upon the rod, *g*, which is connected to the rod, *c*; to release the arm, *a*, the nut, *f*, is turned partly round, so to admit of its oblong head being drawn through the bar, *e*. Steam is admitted into the apparatus through the pipe, *a*, and the water resulting from its condensation, is drawn off from the body of the shape by the cock, *h*, from one arm by the cock, *i*, and from the other arm by the opening through which the rod, *g*, passes, when it is allowed to escape by unscrewing the nut, *f*: the air is permitted to escape from the apparatus, on the admission of the steam, through the cocks, *h*, *i*, and through a small groove in the face of the nut, *f*, corresponding with the hole in the end of the arm.

Fig. 23.

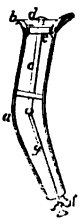

Fig. 24.

Fig. 25.

Fig. 24, is a side view, and fig. 25, a front view of an apparatus to be inserted into the legs of trousers. Steam is introduced into it through the pipe, *a*, and the water is drawn off by the cock, *h*, through which also the air is allowed to escape, on the admission of steam.

PART SIXTH.

DYEING AND CALICO-PRINTING.

CHAPTER I.

GENERAL OBSERVATIONS ON CALICO-PRINTING PROCESSES, MORDANTS, MADDERING, ETC.

HAVING already, in Part III., treated extensively of mordants, it is not necessary that we should say much upon the subject here.

The causes which determine the combination of the mordant with the fabric are either physical or chemical. Among the first, the impression presents defects arising from the fabric, the engraving, the color, and the pressure exercised while printing. The more regular and fine the texture of the fabric, the more perfect the impression; if, however, the texture is too close, the mordant cannot penetrate thoroughly, but remains on the surface in scales, which partially peel off, and only gives, upon dyeing, dull and unequal colors.

With regard to the engraving and pressure, what we are about to state concerning cylinders applies equally to block-printing. If the engraving on the cylinder is not of equal depth throughout, unequal shades will be produced. The cause of this defect has been turned to advantage, in order to obtain two different shades with a single cylinder and color; it is sufficient, for example, in order to produce, with the same cylinder, red and pink, to engrave those parts which are to

produce the latter tint less deep than those which are to produce the red. As this kind of design, which is very difficult to engrave, furnishes for the lighter shades very little color, it is almost impossible to obtain them uniform and without spots or inequalities, which is more perceptible after the brightening process; it is therefore chiefly employed for deep blues, &c. The manner of engraving also greatly influences the intensity of the colors. *Bitten* and *outlines* always produce deeper shades than what is technically called *chalk engraving*, as the latter takes up less color than the others.

The speed at which the cylinder is driven must also be taken into consideration, as the faster it revolves the lighter the shades, because it deposits less color upon the fabric. If the pressure upon the roller is too great, the color is not fixed upon the fabrics, and produces, on dyeing, unequal shades; if, on the other hand, the pressure be too light, the same defect is produced, but from a different cause, as in the latter case, the color merely touches the fabric, and does not penetrate, but remains on the surface, and ultimately falls off.

This method of printing is subject also to another very serious inconvenience, that of producing unequal shades, arising from the action of the pressure cylinder upon the engraved cylinder never being perfectly uniform; and this defect, which may be avoided by great pressure, appears on the contrary in all its force when the pressure is too light.

Hence we see the importance of uniform pressure, in order to obtain a uniformity of shade. This defect in printing may be ascertained by examining both selviges of the fabric, which ought to be precisely similar; if one is of a deeper shade than the other, the pressure is not uniform.

The defects arising from the color depend upon its thickness and the nature of the mordant. If the color is too thick, it cannot enter into the lines of the engraving; if too thin, it runs and spoils the design: a medium between these must be found, *which long experience alone can teach*, and which varies not only with each kind of fabric (the color being thinner in proportion as the texture is fine), but also with each kind of design; for the more the design is charged, the thin-

ner the color must be; for this reason, designs printed on a colored ground, can only be well done with gum colors, as those with starch cannot, without being decomposed, be diluted beyond a certain limit, which is not adapted to obtain the desired object.

The substances generally employed as *thickeners* are the following:—

1. British Gum (roasted starch).
2. Calcined potato starch.
3. China-clay, mixed with gum arabic or gum senegal.
4. Dextrine.
5. Gum arabic.
6. Gum senegal.
7. Gum tragacanth.
8. Pipe-clay, mixed with gum arabic or gum senegal.
9. Rice starch.
10. Salep.
11. Sago, common and torrefied.
12. Sulphate of lead, mixed with gum arabic or gum senegal.
13. Wheat starch.

Colors thickened with gum have the defect of producing, during printing, a great deal of froth, which, if not removed as fast as it forms, becomes fixed upon the fabric, and only produces feeble colors, as it contains but little mordant. Starch colors froth up very little, and this may be easily prevented by adding a little sulphate of lead, which appears to act in dividing the mass. The thickeners also exercise respectively a peculiar action upon the mordants: thus, a color which, thickened with starch or flour, is very deep, is less so when thickened with gum or roasted starch; this latter substance, in dyeing, gives less brilliant shades than starch or gum. Gum tragacanth, dextrine, salep, and sugar, act precisely in the same manner, and produce brilliant colors.

The physical causes of the defects occasioned by the drying of the pieces after printing, arise from excess or deficiency of heat, and the stagnation of the air. The drying must take place as rapidly as possible, in order to prevent the colors from spreading upon the fabric, and spoiling the design; and, for this purpose, the stoves are usually heated to 30°

Reaumur,* in order to dry the pieces directly. Care must, however, be taken *not to exceed that temperature, which is known by experience to be the best for mordants, especially for the aluminous ones;* as, by that means, the colors might become incrusted, and fall from the fabric, which is particularly the case with those prepared with gum. A less degree of heat is maintained when the cylinders are charged with very strong iron mordants, or steam colors, and especially ground colors, which are the more brilliant the more slowly they are dried..

The air must be renewed as often as possible in the stoves, in order to carry off the vapors of water and acid which are disengaged from the printed pieces; as the former might spoil the design by damping it, and the latter by transforming the mordant into an acetate, which would not combine with the fabric, and would therefore produce white spots. The same

* The atmosphere of the printing shop should never be allowed to cool under 65° or 70° F.; and it should be heated by proper stoves in cold weather, but not rendered too dry. The temperature and moisture should therefore both be regulated with the aid of thermometers and hydrometers, as they exercise a great influence upon all the printing processes, and especially upon the combination of the mordant with the cloth. In the course of the desiccation, a portion of the acetic acid evaporates with the water, and subacetates are formed, which combine with the goods in proportion as the solvent principle escapes; the water, as it evaporates, carries off acetic acid with it, and thereby aids the fixation of bases. These remarks are peculiarly appropriate to delicate impressions by the cylinder machine, where the printing and drying are both rapidly effected. In the lapis lazuli style, the strong mordants are apt to produce patches, being thickened with pipe-clay and gum, which obstruct the evaporation of the acids. They are therefore apt to remain, and to dissolve a portion of the mordants at their immersion in the blue vat, or at any rate in the dung bath. In such a case, a hot and humid air is indispensable, after the application of the mordants, and sometimes the goods so impregnated must be suspended in a damp chamber. To prevent the resist pastes becoming rapidly crusty, substances apparently useless are mixed with them, but which act beneficially by their hygrometric qualities, in retarding the desiccation. Oil also is sometimes added with that view. It is often observed that goods printed upon the same day, and with the same mordant, exhibit inequalities in their tints. Sometimes the color is strong and decided in one part of the piece, while it is dull and meager in another. The latter has been printed in too dry an atmosphere. In such circumstances a neutral mordant answers best, especially if the goods be dried in a hot flue, through which humid vapors are in constant circulation.—*Ure.*

observations apply to the stretching, in which the pieces are hung up for several days after printing, before dunging, in order to combine the mordant with the fabric; the temperature must not exceed 10° or 15° Reaumur, and the air must be sufficiently damp, that, in cooling, the pieces may be folded without any rustling; they must not, however, be too damp, as in that case the mordant would run. A certain degree of humidity, which may be known by experience, and which can be ascertained by a hydrometer, is indispensable to the union of the mordants with the fabric, particularly when they have a base of iron, tin, iron and alumina, or tin and alumina.

The action of the air upon the fabrics, while hanging to dry, is chemical,* although produced by physical causes: in effect, the damp air penetrates the stratum of color, softens it, and carries off the acetic acid of the mordant, leaving the alumina with which it was chemically combined, but not yet in combination with the fabric, as it only combines therewith by a suitable degumming operation, without which only dull and feeble colors are produced.

At the degumming operation, the purely physical causes which influence the combination of the mordant with the fabric, cease; they are so closely allied to the chemical causes. *that it is only by a long and persevering study of their action that the point where the former end, and the latter begin*, can be ascertained. It appears that the degumming operation acts in a different manner, according to whether the pieces are submitted thereto immediately after printing, or after hanging to dry for forty or fifty hours.

The action is chemical and mechanical; chemical in the first instance, because, if chalk or some other carbonate be not added to the dung-bath in sufficient quantity to saturate all the acid of the mordant, the latter will detach itself from the fabric, and become dissolved in the bath,—mechanical, *because it facilitates the combination of alumina, either pure or in the state of a sub-sulphate, with the surface of*

* See chapter I. Part III.

the threads of the fabric. This assertion is confirmed by the fact, that the centre of almost all dyed threads remains perfectly white, or nearly so, the coloring matter scarcely ever going beyond the surface.*

In the second case, all the acetic acid being separated from the mordant, the dung only is employed; the action of which is, probably, merely mechanical.

The mechanical action of the dunging is not solely confined to the union of the alumina with the fabric by rendering it insoluble; but it also carries off a portion of the mordant not combined with the fabric; and likewise dissolves the thickening matter, which contains a considerable quantity of it.† For this reason, the degumming operation may be performed with equal advantage either with bran, dung, or even by running water alone: this latter, which acts very slowly, especially in winter, is used chiefly for light colors, prepared with gum or torrified starch; it has, besides, the disadvantage of allowing the mordant, which flies off from the impression, to fall upon the white parts of the piece and stain them, if the least fold or crease should be formed.

If there were no other action in the operation of degum-

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* See chapter I. Part III., article *Union of Cotton with Coloring Matter.*

† One process for effecting the complete removal of the unprecipitated mordant consists in simply drawing the dried goods through a warm emulsion of cow-dung and water. The emulsion is usually contained in two stone cisterns, each about six feet long, by three feet wide and four feet deep: that in one cistern contains about two gallons of dung, to the cistern-full of hot water; that in the second contains only half this proportion of dung. The cloth, on being taken from the *ageing* room, is first drawn pretty quickly through the emulsion containing most dung, and immediately afterwards through the other; the cisterns being usually placed end to end, to allow the cloth to be conducted directly from the first to the second. The time of immersion, the temperature of the mixture, and the number of pieces which may be passed through a given quantity of dung and water, depend entirely on the state and quality of the mordants, and on the nature of the thickening paste by which the mordants are applied. A piece of cotton with a mordant which has a strong acid requires a longer time than a piece the mordant on which has a weak acid; and when the thickening paste for a mordant is flour or starch, a higher temperature is required than when British gum or common gum is used. The usual temperature of the dung emulsion is 160° or 180° F.—*Parnell.*

ming than that just pointed out, one would be led to imagine that the pieces would be perfectly dyed in the madder bath, without degumming, as the madder possesses the same properties as the dung, which are all that are requisite for carrying off the thickening matter and the excess of mordant, and for allowing that portion which remains upon the fabric to become permanently fixed; but it is not so; the madder-dyed pieces never give good results, unless previously degummed; feeble colors, and imperfect and stained designs, are produced. This circumstance, contrary in appearance to the theory which has now been adduced from facts, is easily explained, on comparing the action of the dung-bath with that of the madder-bath. As the pieces are put into the dye-bath while it is in a cold state, and before the mucilage has become dissolved, the thickened colors, being diluted without being dissolved, are detached by the movement communicated to the pieces, and carry off nearly all the mordant they contained; while, by the dunging operation, nearly all the mordant is fixed in the fabric, when the bath is sufficiently hot to carry off rapidly the thickening matter dissolved therein; and, moreover, all the excess of mordant which, in the dunging operation, is rendered insoluble, and carried off by the animal and vegetable mucilage, not meeting with that of the madder in solution, which would also take it up, falls back upon the fabric, combines therewith and stains it. The six following experiments confirm this theory:—

A piece of ordinary calico, which had been printed about a week with an aluminous mordant, thickened with starch, was divided into six equal parts, of about 8 inches long by 4 wide, and treated as follows:—

No. 1,—Degummed, at a temperature of 12° Reaumur, in a dung-bath, prepared 12 hours previous, with 500 grammes of dung to 4 quarts of water.

No. 2,—Degummed also in a similar bath, but heated to 50° Reaumur.

No. 3,—Was placed, without degumming, at a temperature of 12° Reaumur, in a madder-bath composed of 32 grammes of madder, of the best quality, to 4 quarts of water.

No. 4,—Was placed, without degumming, in a madder-bath, similar to No. 3, which had been prepared, in a cold state, 12 hours previously.

No. 5,—Was placed, without degumming, at 30° Reaumur, in a bath composed of 64 grammes of madder and 125 grammes of dung, to 4 quarts of water.

No. 6,—Was degummed in water only, at 12° Reaumur, and dyed like No. 3.

Nos. 1, 2, and 6, after being degummed, were beaten, washed, and then dyed separately, in a similar manner to No. 3. With the six pieces, the dye-bath was raised in three-quarters of an hour to 80° Reaumur, at which temperature it remained during 15 minutes; they were afterwards soaped, then brightened, and soaped a second time.

Results.—Nos, 1, and 2, were equal in beauty; in No. 3, the impression was imperfect, and the ground stained; in No. 4, the tint was as uniform as No. 1, but with only half the depth of color: this arose, no doubt, from the mordant flying off, and combining with the madder, thereby rendering a portion of its coloring matter insoluble. No. 5, tint so feeble as to be scarcely perceptible, caused by the absorption of the coloring matter of the madder, by the ligneous part of the dung. No. 6, as fine as No. 1.

Let us now examine the processes of degumming most frequently employed. The operation of dunging is ordinarily effected between 30° and 65° Reaumur, in a wooden vat, 6 feet long, and 5½ feet in width and depth, filled with water; in which, for 40 pieces of 50 yards each and ¾ wide, about 60 quarts of dung are dissolved, which is at the rate of three pints to each piece; they are passed through this for a quarter of an hour, taken out, rinsed, and beaten; they are then ready for dyeing, or to be again passed through the dung, to ensure, if necessary, a more successful operation. There is no disadvantage in employing more than 60 quarts of dung for 40 pieces; but a less quantity must not be employed, as, in that case the mordant, which leaves the fabric, not finding the mucilage necessary to precipitate it, falls back upon the fabric and stains it.

The temperature at which the degumming should be performed is not very important, provided it be not lower than 30° Reaumur; for, in that case, its action would be very slow, there being no action from 0° up to 10°, as the mordant runs upon the fabric before the thickening matter is softened. When chalk or pipe-clay is added, it must be in the proportion of 500 grammes for each piece.

The time necessary for the pieces to remain in the degumming vat is, in general, a quarter of an hour; it must, however, be prolonged in proportion to the temperature of the bath.

In roller vats,* the pieces only remain two minutes, the action of the bath being so uniform upon the whole piece, that the effect is almost instantaneous.

The same observations apply to degumming with bran and with the dunging salt; which process is effected upon forty pieces, with 15 kilog. of bran,† or with 250 grammes of salt; care being taken to boil the first, in order to spread its mucilage throughout the bath, and to dissolve the second. With regard to the degumming by cold water, which is the most simple,—it consists in plunging the pieces in running water, keeping them well spread out, and leaving them there until all the thickening matter is removed; they are then carefully washed and beaten, before dyeing: but this is neither an economical nor a certain process; for the least crease in the fabric forms a stain, because the excess of mordant not being carried off by the water, becomes deposited upon the fabric, and remains attached thereto.

Degumming, by the use of chalk or pipe-clay only, is chiefly employed with iron mordants; it is liable to cloud aluminous mordants, probably because it combines with them in small quantities; what induces this belief is, that pinks degummed by the use of chalk have always a veiny tint.

The greater the quantity of mordant employed, the less intimate is its combination, and, in consequence, the more easily detached, which is frequently proved when carrying on the process of dunging too rapidly; in that case, designs with two shades of the same color, one over the other, lose the more intense shade, which becomes dull and lighter than the other; it is to avoid this defect, that pieces printed with several colors are degummed twice, and even three times, in succession.

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* See next chapter, *Buchanan's Patent*, and *Leese's Patent*, Plate II.

† See Appendix, article *Bran*.

On coming from the dunging-vat, the pieces are washed several times in running water, beaten for a quarter of an hour, and washed again to remove any particles of mordant or dung which might adhere to them: they may then be dyed.

Experience has shown, *that the degumming by dung gives the best results;* and this substance being very susceptible of change, according to the kind of food taken by the cows, it may be concluded that its action is not always the same. In fact, we are of opinion that a variety of accidents in dyeing, attributed to the maddering, are owing simply to the use of dung, *formed from matters which has changed its nature;* and as long as this substance is employed for such a purpose, the process will always be liable to very injurious variations. It is therefore necessary to remedy this evil, of which the extent may now be appreciated.

Although the objects of the operation of dunging are sufficiently apparent, says Mr. Parnell, yet the precise manner in which they are attained is involved in some uncertainty. According to an analysis by M. Penot, cow-dung contains the following ingredients in 100 parts:—

Woody fibre	26·39
Albumen	0·63
Chlorophyl	0·28
A sweet substance	0·93
A bitter matter	0·74
Chloride of sodium	0·08
Sulphate of potash	0·05
Sulphate of lime	0·25
Carbonate of lime	0·24
Phosphate of lime	0·46
Carbonate of iron	0·09
Silica	0·14
Water	69·58
(Loss	0·14)
	100·00

Maddering.—There are seven principal points to be considered in the process of maddering:

1st.—The quality of the water to be employed in dyeing.

2nd.—The quantity of water to be used with a given proportion of madder.

3rd.—The degree of temperature most favorable to the operation.

4th.—The length of time necessary for the dyeing process.

5th.—The effect produced by lowering the temperature of the bath.

6th.—The quantity of madder necessary for the saturation of a given proportion of mordants.

7th.—The degree to which it is necessary to heat the dye-bath, in order to extract the coloring matter.

I. The nature of the water to be employed in dyeing, should be carefully studied, as it materially affects certain colors. Thus, for example, perfectly pure water, possessing no re-agent, is the best for all madder dyes, with respect to the brightness of the colors, except violet. Calcareous water, on the contrary, will not produce such fine reds and pinks as pure water, the colors produced by it being always more or less dull and tinged with violet; but it produces much better violets than pure water. There are two kinds of calcareous water; the one holding sulphate of lime in solution, and the other charged with carbonate of lime: the former cannot be used, as it tarnishes the shades, and precipitates the soap bath, which alone gives to the madder-dyed colors the required brightness: the latter can always be used, whatever may be the quantity of carbonate with which it is charged.

Water charged with metallic salts must not be used; ferruginous water, for instance, if employed, would decompose the soap-bath, tinge all the aluminous mordants a violet hue, and stain the white parts of the fabric.

Sulphurous water is likely to injure and stain iron mordants, provided it does not contain any metallic salts in solution.*

Experiments have been made to test the action of certain substances when added to the madder-bath, and the result

* See chapter II. Part III., article *Purity of Water.*

has been unfavorable in all cases; perhaps these substances have been added in too great quantity in proportion to the madder employed. The experiments made were as follows:—

1. A mixture of 31 grammes of nitric acid, at 40° Baumé, and a quart of cold water, was thrown upon 500 grammes of madder, and the whole well stirred.

2. The next day, 186 grammes of this mixture were diluted with 8 quarts of water; the specimen dyed therein (with all the precautions taken,) was of a lighter red than another piece dyed with one-third of that weight (viz. 62 grammes) of unprepared madder.

3. On increasing the quantity of acid, it was found to remove the mordant, and render the dyeing operation impossible.

4. 31 grammes of olive oil soap, and 62 grammes of madder, only produced a very feeble color.

5. 31 grammes of glue dissolved in water, and 62 grammes of madder, produced but a dull light red. This result was surprising, inasmuch as this mixture was recommended by *Berthollet*, as being almost as favorable to the operation as galls.

6. 186 grammes of a mixture composed of 31 grammes of Tuscany potash, 500 grammes of madder, and one quart of water, produced a very light pink tinged with lilac.

7. 186 grammes of a mixture made with 31 grammes of slacked lime, 500 grammes of madder, and one quart of water, produced a very light yellowish pink.

8. 186 grammes of a mixture made with 500 grammes of madder, and one quart of water, containing 31 grammes of sulphuric acid, at 66° Baumé, furnished a very light pink, and carried off the mordant in several places.

9. 31 grammes of chalk, and 62 of madder, furnished a very light dull red.

The substances were added to the dye-bath in large quantities, in proportion to the weight of the madder, in order to be able to judge more accurately of the action of each of them; but their comparative utility was lost sight of, as at least two of them, viz. chalk and glue, are known to be useful. These experiments are so delicate, that, to arrive at definite conclusions, mere experiments in the laboratory are not sufficient,—they must be made on a large scale.

Besides, many circumstances may alter the action of the substances added to the madder-bath, for the purpose of drawing from it the greatest possible quantity of coloring matter; at least, we are led to believe this, from the following experiments made for the purpose of discovering in what state galls are most advantageously employed in maddering:—

On mixing 31 grammes of pounded galls, or sumac, with 62 grammes of mad-

der, in 8 quarts of water, the alumina mordants dyed therein only take a dull brown color; while if, after dunging the fabric, it is passed for a quarter of an hour through a bath at 80° Reaumur, made with the same quantity of galls, and afterwards dyed with the same quantity of madder as in the preceding experiment, a fine red is obtained, deeper than that of a third specimen, dyed in the same manner, but without having been previously galled. By adding a solution of galls to the mordant, before printing, scarcely any mordant remains in the fabric after dunging.

It may be concluded from these facts, that the galls only exert all their influence on the coloring matter of the madder, when combined, before dyeing, with the mordant previously fixed in the fabric by degumming. It is probable that in the first case, the galls hindered the dyeing operation by precipitating the coloring matter, and that in the second, they facilitated it by increasing the absorbent properties of the mordant. This would perhaps explain the well known fact, that fabrics dyed twice are always of a deeper and brighter color than those only dyed once, although the same quantity of madder be employed. In the third case, the galls prevented the mordant from being properly fixed in the fabric, because by its infusion it precipitated the aluminous salts. Wheat bran, coarsely ground, mixed with the dye-bath, in equal quantity to the madder, will produce a tint of not half the depth of that obtained with the same quantity of madder alone; on the other hand, the white part of the fabric is much less charged with color, provided the precaution be taken of washing it immediately on coming from the dye; without which, the coloring matter will become fixed with such tenacity, that it is almost impossible to separate it. Dung, added to the dye-bath, produces the same effect as bran.

II. The most advantageous quantity of water to be employed with a given quantity of madder can only be determined by approximation; "experience shows," says a recent writer* upon this subject, "that 30 quarts are necessary for every pound of ordinary madder." No disadvantage has been found to arise, either from increasing or diminishing the quantity of madder, relatively to this quantity of water, up to cer-

* M. Giradin.

tain limits, beyond which the coloring matter will not unite with the fabric, as it is carried off by the excess of water, or retained by the mucilage of the madder, which prevents it from dissolving.

III. The degree of heat suitable for commencing the dyeing operation, is a matter of much dispute among practical men; some maintain that it must be as high as 30° or 40° Reaumur; while others, who form the majority, contend that it is better to dye with a cold bath: all, however, agree that it must neither be down to 0°, nor up to the boiling point. In order to arrive at a correct conclusion on this head, the following experiments were made:—A piece of calico, perfectly bleached, was cut into pieces of about 16 inches long, and ten wide. All these pieces were immersed together in pure acetate of alumina, at 10° Baumé, for about five minutes, pressed, wrung by hand, and hung up in a rather moist drying apparatus at 15° Reaumur, for two nights and three days. The third day they were dunged at 65° Reaumur, and then severally dyed in baths, prepared in a copper vat, with 8 quarts of pure water, and 31 grammes of the best madder, and stirred constantly, during the dyeing, with a small fir stick. The temperature of each bath was indicated by a thermometer.

No. 1 put in at 10° R. heated in 1 hour to 80°, and taken out.							These three specimens were of a uniform light red tint.
No. 2	"	20°	"	"	"	"	
No. 3	"	30°	"	"	"	"	
No. 4	"	40°	"	"	"	"	Of a uniform red, but a richer color than the three preceding.
No. 5	"	50°	"	"	"	"	
No. 6	"	60°	"	"	"	"	
No. 7	"	70°	"	"	"	"	Deeper than No. 6.
No. 8	"	80°	"	"	"	"	The same tint as No. 6.

These experiments prove that it is better to commence the operation above 30° R. than under it; this fact is corroborated by *practical experience*, which shows that great economy is effected in the madder bath by raising the temperature to 40° R.; moreover, that the most advantageous heat for commencing the operation is 70° R. It is, however, to be

regretted that it cannot be employed on a large scale with facility, as the workmen are not able to fasten the pieces together, end to end, at so high a temperature, without burning themselves; it is besides probable that this degree of temperature would produce stains, especially for designs with a ground; the movement of the piece not being sufficiently rapid to plunge all parts of it into the dye-bath at the same time, the action of which would, no doubt, be almost instantaneous. It will be seen presently that this degree (70° R.) is also the most advantageous temperature *at which to stop the operation;* lastly, that the boiling point, far from being favorable to the combination of the coloring matter with the mordant, seems, on the contrary, to separate a portion of that which had already united with it.

In winter, during frost, it is customary to make the madder-bath lukewarm, because it is impossible to dye at 0° R., as the coloring matter does not dissolve properly. If the bath is too cold to melt the small icicles adhering to the pieces speedily (which must always be carefully avoided, as frost affects the mordants), whitish stains will be produced wherever they existed.

IV. The duration of the operation of dyeing varies according to the colors to be produced; it is generally a single dip of three hours for reds, violets, and browns, and two dips, of an hour and a half each, for pinks, the fabrics being put in at 20° or 30° R., which temperature is raised to from 40° to 50° R.

V. The effect of lowering the temperature of the dye-bath, has been ascertained by means of samples prepared as in the preceding experiment. The madder-bath was heated, in a quarter of an hour, to the degree indicated, stirring it constantly; it was then removed from the fire, and left uncovered, for twelve hours, in stone vessels of equal size, to cool; at the expiration of which time, the bath was employed, as in the preceding experiments. In each of these experiments, 31 grammes of the best madder were used. The following were the results obtained :—

No. 1	heated to	10° R.	and left	at that	temperature.			All these pieces were of the same light red tint.
No. 2	"	20°	"	"	"	"	"	
No. 3	"	30°	"	"	"	"	"	
No. 4	"	40°	"	"	"	"	"	
No. 5	"	50°	"	"	"	"	"	
No. 6	"	60°	"	"	"	"	"	
No. 7	"	70°	"	"	"	"	"	
No. 8	"	80°	"	"	"	"	"	This piece did not take the color, being scarcely stained.

It may be concluded from this, that the dye-bath may be lowered a few degrees below the boiling point, without the least inconvenience; *but it is not so at* 80° *Reaumur, as the bath, if heated to that degree, and afterwards cooled, becomes useless.* It would seem that the coloring matter then becomes insoluble; at any rate *the water floating upon the madder* is perfectly limpid, being scarcely tinged with an amber tint.*

It would be interesting to know whether the coloring matter which disappears, is absorbed by the ligneous matter, or retained by coagulated matter; the microscope would be very useful in this inquiry.

VI. The proportion of madder necessary to saturate a given quantity of aluminous mordant, can only be ascertained with correctness when the coloring matter is separated, (as this varies according to the kind of madder, and even in different portions of the same, according to its age, its degree of dryness, the salts it contains, and the treatment it has undergone,) and when a definite combination of that and the alumina has been effected. This is believed to be impossible, judging from the eight experiments made with the precautions above mentioned, excepting that an aluminous mordant of less strength (2½° Baumé) was employed in order to obtain clearer tints.

The experiments were begun at a temperature of 12°, and were heated in an hour to 80° R., and kept at that temperature for fifteen minutes; the pieces were then soaped for a quarter of an hour at 65° R., in 24 quarts of water, with 64

* The madder is precipitated on the cooling of the liquor.

grammes of white soap, then brightened, in the same quantity of water, with a solution of tin in *aqua regia*, washed in running water, and soaped as before. The following were the results obtained:—

No. 1	31	grammes of madder	. . .	bright pink.
No. 2	64	" "	. . . .	light red.
No. 3	95	" "	. . .	intensely bright red.
No. 4	126	" "	. . . .	deep red.
No. 5	157	" "	. . .	little more intense than No. 4.
No. 6	188	" "	. . . .	one-third deeper than No. 4.
No. 7	250	" "	. . .	little deeper than No. 6.
No. 8	500	" "	. . . .	one-fourth deeper than No. 7.

These experiments would seem to prove that the quantity of madder *necessary for dyeing a piece of calico about* 50 *yards long, by* 1 *yard wide, a fine red color, is about* 76 *lbs.;* but experience demonstrates, that from 20 to 24 lbs. suffice for obtaining the deepest red; therefore, in these experiments all the coloring matter was not extracted from the madder, which might be expected, since the operation was performed in one-sixth of the time usually taken when working on a large scale.

Great difficulty is experienced in saturating the aluminous mordants with coloring matter, if indeed they are ever completely saturated, *from which we are led to believe that a definite combination of the coloring matter and the alumina does not exist, and that beyond a certain limit, the intensity of the color is not increased in proportion to the quantity of madder employed;* this is proved by No. 8, the shade of which was only one-fourth deeper than that of No. 7, although the dye-bath was charged with double the quantity of madder.

VII. Experience has shown that the more the dye is heated beyond a given temperature, the less coloring matter is extracted, when aluminous mordants are employed, and the more the shade is deteriorated; but mordants of iron, tin, alumina and iron, and alumina and tin, are not affected by this treatment. These facts being known, the latter are always dyed at the boiling point, and the former at 65° R. as

the maximum; pinks are always dyed at from 40° to 55° R., *their tint being brighter in proportion as the degree at which they are worked is less.*

In order to ascertain the degree at which the coloring matter of the madder begins to unite with the aluminous mordants, and also the degree at which it unites with them in the largest proportion, the following experiments were made with the same precautions as in the preceding operations:—

No. 1 immersed at a temperature of 13° R., left an hour in the bath, continually stirred, and then taken out, was scarcely tinged with a yellowish tint.

No. 2	immersed at 13°	and heated in an hour to	20°—same tint as No. 1.
No. 3	"	"	30°—a fine pink.
No. 4	"	"	40°—pink 4 times as intense as No. 1.
No. 5	"	"	50°—tint twice as deep as No. 4.
No. 6	"	"	60°—same as No. 5.
No. 7	"	"	70°—a much deeper tint than No. 6.
No. 8	"	"	80°—same tint as No. 5.

It is, therefore, at 13° R. that the coloring matter of the madder unites with fabrics treated with the aluminous mordants, and at 70° R. that it combines therewith in greatest proportion; this degree of heat is therefore, as already stated, the most advantageous for immersing the fabric to be dyed. As formerly observed, upon raising the heat to the boiling point, *a portion of the coloring matter which had become fixed in the cloth, will be separated from it;* so that fabrics treated with the aluminous mordants must on no account be dyed at as high a heat as 80° R. The time of immersion may, up to a certain point, be prolonged instead of raising the temperature; *for this reason pinks take a longer time than any other color.* On coming from the dye, the pieces are plunged in running water and well washed, to free them from the coloring matter not combined with the mordant, and which, being merely deposited upon the surface of the fabric, would stain the white parts if suffered to remain.

After this operation, the parts of the fabric which are intended to be left white are still pink; there are two methods by which they may be brought to their former whiteness: according to the first, economy must be sacrificed to the beauty of the shades; and according to the second, the beauty of the

shades to economy. The first is the method pursued in Alsace, and the second in Rouen. It is to be regretted that the present demand, by which everything is required cheap, forces the first to assimilate to the latter.

We will pass over the method of bleaching by exposure in the open air, which is generally abandoned on account of its long duration.*

The method of bleaching in Alsace, consists in soaping the pieces at 50° or 65° R., brightening them, as hereinafter mentioned, and afterwards boiling them once in soap. In summer they are exposed in the fields for a shorter or longer time, say from three to six days, according to the fineness of the weather, and are afterwards dipped and soaped at the boiling point; while in winter, when this plan cannot be adopted on account of the frost, they are boiled several times in soap, after brightening, until perfectly white, which requires sometimes four successive boilings of half an hour each. This treatment, which is expensive, is used for small designs containing black and red, or black, red, and pink, which designs can only acquire the beauty peculiar to those of Alsace by this method.

Pinks, brightened very powerfully, and afterwards soaped under a pressure superior to that of the atmosphere, always present a perfect white, which is not the case with those less brightened, the white of which must, nevertheless, be in the highest perfection, in order not to tarnish the shade of the design, which is generally printed with the cylinder or roller, and to dye afterwards with different coloring matters, which adhere to all those parts not sufficiently bleached.

We believe the action of the soap to be purely chemical,—alkalies possessing the property of dissolving the coloring matter of madder, but not however without altering it; and soap being nothing but a caustic alkali, the action of which has been moderated, by combining it with a fatty body, which retains the coloring matter and prevents it from being again taken up by the fabric. This fact may be ascertained with

* See chapter I. Part II.

certainty by decomposing a soap-bath, which has been well used, by means of an acid,—the fatty acids immediately ascend to the surface, tinged with orange; the bath having (from red) become almost colorless.

It may, therefore, be admitted that the action of the soap, although essentially chemical, is also in a degree mechanical. Soap possesses another advantage, viz., that of giving greater permanency to the colors, rendering them less likely to be attacked in brightening, and above all, that of giving them a brilliancy which they would not otherwise acquire; it is probable that this effect is owing to a combination of fatty acid, coloring matter, and mordant.

Exposure to the open air oxidizes, as is well known, the coloring matter; and if the pieces are too long submitted to its action, the colors grow faint and dull, and would even entirely disappear if exposed for a considerable period.

Attempts have been made to render this treatment more economical by using hypochlorite of lime, either before or after soaping; which in summer does away with the third and last soaping, and in winter with all the operations used for bleaching; besides, by this method, great economy of time is effected.*

The pieces are passed through the hypochlorite immediately after maddering, after the first soaping, after brightening, and either before or after the third soaping, which finishes the operation.

By the first method, the reds are much tarnished, which happens every time they are brought in contact with soluble salts of lime; the black becomes grayish-brown, but a perfect white is obtained.

By the second, and especially by the third, the colors are less changed than by the first.

The fourth is the only one which gives a fine white ground, tarnishing the red colors so little that it may be employed with success; a better result still is obtained by substituting hypochlorite of soda for hypochlorite of lime; the

* See page 213, commencing eighth line from foot.

reds are, however, never so brilliant as those produced by soap alone.

Hypochlorite of lime possesses every advantage for bleaching violets and puces; indeed it is very generally employed for that purpose.

The action of hypochlorites is also oxidizing, but more active than that of the bases of those salts and the chlorine which is disengaged therefrom during the operation upon the coloring matter; and for this reason this operation should be entrusted to experienced hands. Thus, for example, by passing the goods for too great a length of time through hypochlorite of lime, the iron mordants will be carried off by the chlorine: the black and violet colors becoming faint; puce, which is composed of a mordant of iron and alumina, reddens by the dissolution of the iron mordant; mordants of alumina, on the contrary, not being attacked by the chlorine, preserve all their intensity, but are turned brown by the lime, which is the base of the salt.

The method of bleaching practiced at Rouen, consists in alternately passing the fabrics through hypochlorite of lime and bran, or bran and soap. The bran* acts as an absorbent, and acquires a red color as the white parts of the pieces re-appear: it does not alter the red coloring matter.

We have seen that, after dyeing, the pieces are passed through bran or soap before undergoing the brightening process. This operation merely consists in the action of acids of greater or less strength upon dyed fabrics, so as to change the brick-red of those treated with aluminous mordants into a bright red, and the black color of those treated with iron mordants to a fine violet.

To brighten the aluminous mordants for reds, a solution of tin in *aqua regia* is employed; for pinks, a solution of tin and pure nitric acid, or a compound of equal weights of solution of tin and sulphuric acid;—there is no perceptible difference in the results obtained with these various ingredients.

Iron mordants are brightened with sulphuric acid, or with

* See Appendix, article *Bran*.

a solution of tin; this latter, acting more promptly, is rarely used, except in cases where these mordants are combined in the design with aluminous mordants, the tint of which it is desirable to preserve.

In order to brighten the aluminous mordants, the pieces are rapidly plunged in a bath of cold water at 10° R., to which is added a solution of tin, in quantity increasing in proportion to the rapidity of effect and lightness of the shade required. With regard to the quantity of solution to be employed, the temperature of the water must be noticed, and a less quantity added in proportion to an increase of heat; the operation proceeds, and the goods are worked for two or three minutes; steam is then gradually introduced, and the bath heated, until the color is softened to the shade required. The steam-cock is then quickly shut off, and cold water introduced; after which the goods are taken out and washed in running water.

The object of these precautions is to prevent the colors from clouding, which takes place when the brightening bath does not act uniformly upon the whole surface of the goods; the color is therefore apt to become clouded if the brightening bath be heated too much or too rapidly,—if too much of the solution be employed,—if the bath be not well stirred before entering the goods, or if the goods be not washed immediately after brightening.

The action of the brightening process is twofold, as it acts upon the coloring matter and also upon the mordant which fixes it.

The coloring matter is acted upon very powerfully by the solution of tin; nitric acid may therefore be used, in combination with it. From this it may be conceived that the brightening process acts by oxidizing the coloring matter, which is proved by the yellow tint it receives, as is the case with all organic matters containing azote, when attacked by nitric acid.

It should be remarked, that when, after having brightened and soaped the maddered pieces, it is desired again to operate upon them in order to soften down the shades and render

them lighter, very strong brightening solutions are requisite: it appears that the coloring matters acquire great fixity by the process of brightening. This fact is only explained by a change taking place in the nature of the coloring matter, and analogous no doubt, to that of certain salts which abandon the last traces of their acid or base with greater difficulty, in proportion to the presence of a larger quantity of base or acid.

This phenomenon might also be owing to a triple combination of coloring matter, alumina, and fatty matter (of the soap), which would not take place until after the brightening process. What confirms this latter opinion is, that mordants in general, and especially those of alumina, after being soaped, cannot be again dyed, as they will not take up any more coloring matter;—the mordant appears completely saturated.

When designs containing two reds—the lighter over the deeper one—are brightened too much, the former alone remains, and the latter disappears, because the more base the alumina mordants contain, the less affinity they have for the fabric.

Iron mordants must be brightened with the same precautions as those of alumina; it causes them to assume a yellowish-brown tint; they must then be washed in running water, and immersed in a bath of hypochlorite of potash. The action is instantaneous, owing to the excess of alkali.

Mordants of iron, brightened and washed, (but not soaped) and then maddered, are perfectly fast, if the action of the acid has not been carried too far,—for in that case, not only is the coloring matter destroyed, but the mordant itself is carried off; thus rendering a combination of that and the coloring matter impossible. This fact proves that the brightening process acts upon the mordant as well as the coloring matter. Iron mordants, like those of alumina, are the more easily attacked by acids, as they are more powerful in their action. Immediately after the brightening process, the pieces, whatever may be their mordant, are soaped, finished, and then folded for the market.—(See chapter III., Part I., article *Madder*, and chapters II. and III., Part III.)

CHAPTER II.

RECENT INVENTIONS AND IMPROVEMENTS IN DYEING AND CALICO-PRINTING PROCESSES.

DYEING, DRYING, FINISHING, ETC.

At the present time, science and its applications seem to go onward almost together. No sooner is a new fact announced than it is made available for some useful purpose; and never was there an age so fertile in discovery as that in which we live. They may be thought to be of a minor kind; and we cannot perhaps hope that any discovery yet remains to be made of such a character of importance, and vital interest, as to work out a revolution in our industrial relations, equivalent to that effected by the steam-engine. We must expect rather to go on *eking out and completing the fabric of our knowledge by the acquisition of absent details, and by arranging and harmonizing its parts, strengthening evidence and cancelling error*, thus rendering the elements more and more intelligible, serviceable, and of readier access *to the practical man*. But while we do not anticipate any revolutionizing discovery in science or industry, we may still expect that many useful inventions are yet to be made, and improvements to be effected, both in the chemical and mechanical arts and manufactures. These may not be great and brilliant, dazzling the world by their splendor; but they may confer upon us new facilities, and it may be, new advantages of much influence on our social condition. We do not look to physical science as the sole instrument by which that condition is to be elevated to its proper standard; but, operating in conjunction with the moral aspirations which replace in our artisan population the besotted contentment of the serf, we may, without risk of disappointment, an-

ticipate that amelioration awaits us; and that our mechanical ingenuity, instead of being a source of evil and of misery, shall become the blessing of the world, and the safeguard of our physical well being. With these prefatory remarks we pass on to our regular subject.

There is, perhaps, no other occupation throughout the whole circle of the manufacturing arts requiring so extensive a combination of taste, chemistry, and mechanism as *calico-printing*, or the printing of woven fabrics. The combination of three such opposite agencies may sound oddly; but this is the very circumstance which places the operations in so high a rank; since, although we may meet with as fine taste, as dexterous chemical manipulations or as exquisite machinery in many other manufactures, we nowhere find all three combined in so remarkable a manner as in this.

We purpose in this and the two following chapters, laying before the reader a series of very valuable inventions and improvements, in dyeing and calico-printing, recently made in Great Britain and France.*

We have thought it advisable, for the sake of *order* as well as *convenience*, to class the different subjects of each patent under the head of *series*, first, second, third, &c., there being several improvements generally comprised under the same patent: giving the date of each patent as we proceed, to prevent any misconception upon the subject, as well as imposition by interested parties, or those intending to secure patents, in the United States, for inventions and improvements of a similar character.

By taking this course, we enable all who may feel disposed to adopt those inventions or improvements, singly or collectively, for their own especial benefit, to do so without molestation. These observations apply, with equal force, to the various inventions and improvements described in the foregoing part of this work.

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* In chapters V. and VI. of this Part, we shall give everything, of any practical value, *on Calico Printing Processes*, to be found in the works of Dr. Ure and Mr. Parnell, and in a much better form, at least for any practical purpose.

I. The *first series* of improvements* which we shall describe, are of the invention of Mr. John Buchanan, of Rambottom, Lancaster, and consist in "a new arrangement of machinery, by means of which dyeing, and similar operations, are performed in a more efficient and economical manner than by the apparatus now generally in use for such purposes."

Fig. 26, represents a sectional end view of the apparatus.

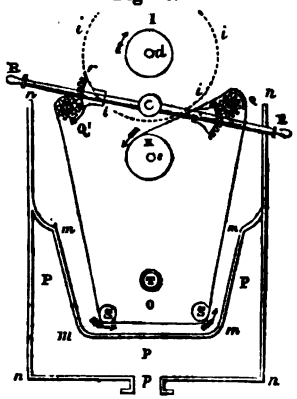
Fig. 27, a sectional side view; and,

Fig. 28, a plan of the machine.

Fig. 29, is an end view of the driving gearing; and,

Fig. 30, similar to fig. 26, showing a modification of the same apparatus, by which the pieces are washed or rinsed at the same time. In figures 27 and 28, A, represents a pulley driven by a strap and connected with the spur-wheel, B, which revolves on the fixed stud or axis, *a*, (fig. 27). E, is a loose pulley moving on the same stud, *a*, on to which the strap may be shifted when it is required to stop the motion of the apparatus. The wheel, B, conveys motion to two similar spur-wheels, C and D, (figs. 27 and 29) which run loose on their respective shafts, *d*, and *c*, fig. 29. F and F¹, (fig. 27) are sliding couplings, the position of which is governed by means of the lever *f*, which vibrates on the fulcrum, G, passing through the fixed stud, *a*, so that in the position of the lever, *f*, as represented at fig. 27, the coupling, F, connects the shaft, *d*, with the spur-wheel, D, while the coupling, F¹, being disconnected from the spur-wheel, C, allows it to run free of the shaft, *c*. But supposing the lever, *f*, to be vibrated, the shaft, *o*, would be connected with the wheel, C, by the coupling, F¹, and the shaft,

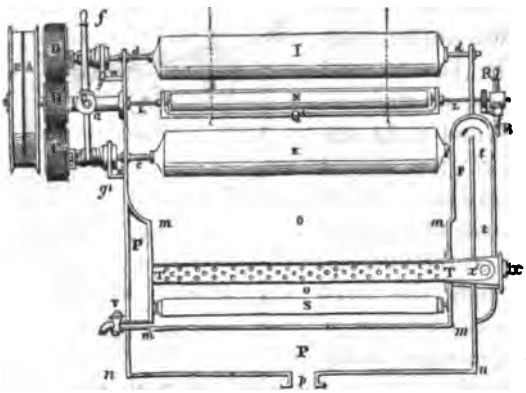
Fig. 26.



* Patented in June, 1836.

d, would be free. At the opposite end of the coupling, F, and F¹, to that at which they connect the spur-wheels, D and C, with the shafts, *d* and *e*, as already described, is placed the friction clips, *g* and *g*¹, which run free of the fixed studs, H and H¹, when either coupling is in connection with the spur-wheels, D or C, but when that is not the case, the stud, H, or H¹, impedes the rotation of the shaft on which such coupling is placed as would be the case with the shaft, *c*, as represented in fig. 27, where the coupling, F¹, is disconnected from the spur-wheel, C, and the clip, *g*¹, is in contact with the stud, H¹. The position of this driving gearing will be seen in an end view at fig. 29, where the same letters indicate the same parts as already stated. On the shaft, *d*, is placed a wooden cylinder, I, and perpendicularly under it on the shaft, *c*, a similar cylinder, K, which partakes of the motion of their respective shafts. The whole of the above described gearing is supported in an oblong cast-iron vessel, the shapes of which may be seen by the letters *n*, *n*, *n*, *n*, in figs. 26, 27, and 28, the lower part of which vessel is provided with an interior casing or division as represented at, *m*, *m*, *m*, *m*, figs. 26 and 27, which divides the vessel, *n*, *n*, *n*, *n*, into an interior chamber, O, and an exterior chamber, P, the latter of which is a steam-chamber, as will be hereafter described. Independent of the driving gearing of this apparatus, but parallel to the shaft, *d*, are placed the shafts, L and M, (figs. 27 and 28) which are provided with the cylinders which run free on the respective shafts. On the same shafts, L and M, are placed

Fig. 27.



and firmly attached, by set screws, the stretching-bars, Q and Q[1], the position of which (as best seen at fig. 26,) is governed by the vibration of the lever, R, R, which is provided with the racks, *r*, *r*, taking into pinions or spur-wheels at the extremities of the respective rods, L and M. S, S, are guide rollers running free at the lower parts of the interior chamber, O. We shall now proceed to describe the mode of operating with this machine for one description of work, noticing such parts as have not been already described as we proceed. Supposing it therefore be required to dye the ordinary description of calicos, after they have received the mordant from the printing-machine, and the driving-geering of the apparatus to be in the position represented at fig. 27, about twenty pieces of calico sewed end to end must be wound or run on the roller, I, which will then fill a space as indicated by the dotted line, *i*, *i*, figs. 26 and 30. The amount of goods to be operated on being thus uniformly and smoothly placed or wound on the cylinder, I, the driving strap is traversed to the loose pulley, E, and the end of the goods passed over the guide-rollers, and under the rollers, S, S, at the bottom of the chamber, O, from which it is again brought up and passed over the stretching-bar, Q, and attached to the lower cylinder, K. The interior chamber, O, is then filled up nearly to the top, with such dyeing solution as is required, see figs. 26 and 27, and steam admitted to the exterior chamber, P, through the aperture *p*. By this means the dye-liquor in the interior chamber is gradually heated till it arrives at the

Fig. 28.

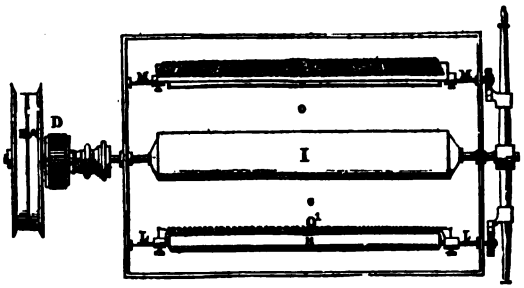
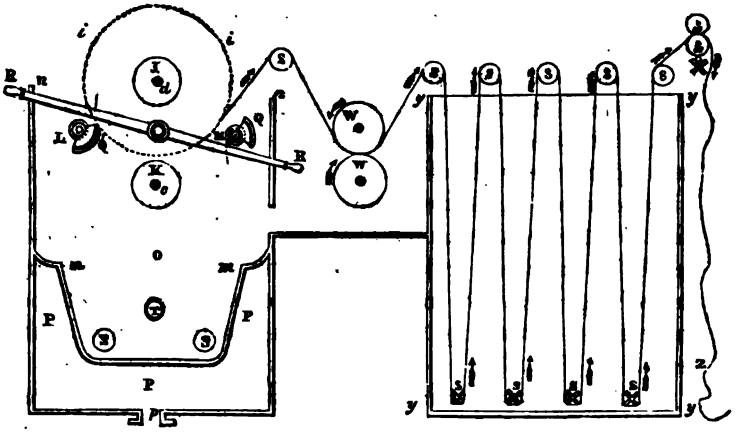


Fig. 29

boiling point. But should it be required to accelerate the heating process, steam may also be admitted to the interior chamber through the tap, *x*, which connects with the dye-liquor by means of the perforated tube, T, T, and with the steam-chamber, P, by means of the opening, x^1, (fig. 27) when turned opposite to the channel, *t*, *t*. This channel, *t*, *t*, is connected with the chamber, P, in the direction of the bended arrow, seen at fig. 27, and is carried to an elevated position for the purpose of preventing any slight condension in the steam-chamber, P, allowing the atmospheric pressure to force the dye-liquor into the steam-chamber should such occur. In fig. 27, the tap, *x*, is represented as shut. The dye-liquor being placed in the interior chamber, O, and the cloth arranged as already described, the position of the lever, *f*, is reversed, by which the coupling, F, and the wheel, C, are connected at the same time that the coupling, F, is liberated from the wheel, D, and the friction clip, *g*, brought in contact with the stop, H. The driving strap is then placed on the driving pulley, A, and motion imparted to the cylinder, K, on to which the goods are regularly wound or received over the stretcher, Q, in an uniform and smooth state, having first passed through the dye-liquor until the whole amount originally placed on the upper roller, I, is unwound; as soon as this is effected the operator vibrates the levers, R, R, which reverses the position of the stretching-bars, Q and Q^1, at the same time that he reverses the position of the lever, *f*, thereby arresting the motion of the cylinder, K, on which the goods are now deposited and imparting motion to the cylinder, I, which again receives them in a uniform and smooth state over the stretcher-rod, Q^1, which has already been elevated for that purpose. Thus the goods are alternately transferred through the dye-liquor from the cylinder, I, to the cylinder, K, and the reverse until the process be complete, when they are taken off the cylinder, I, and replaced by others, and when it is required to renew the dye-liquor it may be run off at the tap, *v*. During this process the steam is turned into the chamber, P, by a separate tap, and admitted or not to the chamber, O, according to the judgment

of the operator, and the nature of the work to be performed. Fig. 30, represents a modification of the invention seen in the same section as at fig. 26, with the addition of a water-tank

Fig. 30.



provided with a series of parallel carrier rollers marked S, above which the goods are passed, and under the corresponding ribbed rollers at the bottom of the vessel, *y*, *y*, *y*, *y*. To put this part of the invention into operation, it is required, as soon as the dyeing process is completed, to detach one end of the goods from the roller, K, and pass it over the guide pulley, S, and through the squeezers, W, W, (fig. 30) and thence forward in the direction of the line indicated by the arrows. The rollers, *w*, *w*, may be driven in any convenient manner. As the rollers, *w*, *w*, deliver the cloth it is deposited on the floor at Z. While this part of the process is proceeding, the vessel, *y*, *y*, *y*, *y*, is supplied with a continuous stream of fresh water, which is kept in a constant state of agitation by the levers or beaters on the rollers, S, at the lower part of the vessel, and the goods are deposited by this modification of the invention, at the point, *z*, in the same state as those which have been subjected to the operation of winching in the ordinary manner. From the foregoing description of the construction and mode of operating with this apparatus, it will be obvious to dyers, printers, and persons conversant with

this description of machinery, that it is equally applicable to *dunging*, *braning*, *soaping*, and all similar processes. It should be remarked that by heating the dye-liquor from a steam-chamber, its strength is not deteriorated as is the case when entirely heated from steam admitted in the ordinary manner. Added to which advantage a very reduced quantity of dye-liquor is sufficient to dye the same quantity of goods, and there is no risk of damage to the pieces during the process. The space also is less than that required by the ordinary apparatus, and "the steam," according to the patentee, "is diminished about two-thirds, and consequently the expenditure of fuel, while the labor of the operative is diminished nearly in an equal ratio." The extra work performed and the saving of dyeing material are equally important, but these must necessarily vary according to the nature of the work.

II. The *second series* of improvements* are of the invention of Mr. Joseph Leese, Junior, of Manchester, and consist, firstly, in the application of a simple apparatus or moveable frame-work, upon, over, or around which the pieces of calicos or other fabrics are to be wound or distended, for the purpose of being *washed* while immersed and working in a cistern or tank of water. This frame-work, with the piece distended upon it, is so constructed and arranged, that the piece is pressed against the body of water, forming a resistance sufficient to wash or cleanse the piece in the most effectual manner.

And secondly, in a peculiar arrangement of frame-work and rollers, both in and outside of the dye vats, in that particular process of the art in which the pieces are to be dyed of a dark blue color, with indigo, called *navy blues;* and in those cases also where a white yellow or other color having been previously printed upon them; have to be preserved; that is, the printed surface of the cloth protected from all contact and friction during the blue dipping or dyeing process.

* Patented in March, 1839.

This improvement is to be performed by a simple and peculiar arrangement of apparatus, in order to pass the pieces through the indigo vats; and which is to be driven or impelled by machinery, the pieces always preserving a continuous progressive motion, instead of hooking them upon a frame, and dipping them by hand in certain portions at a time.

By the peculiar arrangement of the apparatus which constitutes this part of the invention, the printed pieces are always made to pass through the blue dyeing process, with the back side or unprinted surface towards the leading or conducting rollers, so that any dragging or smearing of the printed color or *resist*, (which must otherwise happen if such color, being wet, rubs against a roller) is entirely prevented.

And thirdly, these improvements consist in a peculiar method of discharging *dark* or *navy blues*. In Plate II., fig. 1, represents a sectional elevation of a water cistern and frame-work, for washing the pieces; fig. 2, represents a slight modification of the apparatus for effecting the same purpose; and fig. 3, represents the peculiar arrangement of pieces, vats, frames and rollers, for indigo blue dyeing or dipping.

The washing apparatus, as shewn in fig. 1, consists of a cistern *a*, *a*, into which the frame *b*, *b*, is suspended by a pivot, fixed in a strong rail or bar, fastened to the sides of the frame, and resting on either side of the cistern; on this pivot the frame is made to vibrate.

There are also attached to the frame a series of rollers *d*, *d*, over which the pieces to be washed are distended; at one end of the frame is fixed a pair of drawing rollers *e*, *e*, to draw the piece through the cistern; these move with the frame, so that when the vibratory or pendulous motion is given to it, any sudden jerk or irregularity in the moving of the piece through the cistern is prevented.

When pieces are to be washed, (water being admitted into the cistern through the tap *f*,) they are threaded over the rollers of the frame, and drawn through the cistern by the drawing rollers, at the same time the vibratory motion is given to the frame, and the piece, as it moves forward, is

pressed against the water; the amount of this pressure, and the flow of the water against the piece, being regulated as may be required, by the speed at which the frame is made to move. Should it be found, in any case, that owing to the resistance of the water, the pull upon the piece, in being drawn through the cistern, is too great, the drawing rollers must work only at intervals, that is to say, the piece must first be wound on the frame, which, when filled, must be put in motion till the piece shall be sufficiently washed, then again drawn through the drawing rollers, and thus the frame, being re-filled with fresh cloth, is again to be set in motion.

Fig. 2, is similar to fig. 1, in its principle, as far as relates to the pressure of the piece wound on a frame against the water in the cistern, but the mode of its operation is different, and as follows:—*a*, *a*, is the water cistern; *b*, *b*, is a frame, which rests in the cistern on four wheels, *d*, having flanges to them; at the bottom of the cistern are short iron bars or rails, *c*, on which the wheels run, so that the frame may be moved backwards and forwards in the cistern.

When pieces are to be washed, they are drawn through the rollers of the frame by the drawing rollers, and the frame is moved horizontally backwards and forwards, running upon the rails at the bottom of the cistern; the drawing rollers may, with this machine, as with fig. 1, work continuously or at intervals, as may be required.

In fig. 3, *a*, and *b*, are two vats, into which indigo is put, together with such other ingredients as are commonly used by printers and dyers, to prepare it for the purposes of dyeing; where a dark shade of blue is required, these vats must be longer and a little deeper than those commonly in use, the size being entirely regulated by the shade of color. *c*, *c*, and *d*, *d*, are two frames, which are to work in the vats, having on them a series of rollers, *e*, *e*, *e*, arranged in a transverse or slanting direction, as shown in the figure.

At a considerable height above the vats, and directly over them, in a fixed frame, are placed another series of rollers, *f*, *f*, *f*, *f*, *f*, *f*, slanted the reverse way of those in the vats.

The height of these rollers must be so arranged with the speed at which the piece is to move through the vat, that there shall be sufficient time for the piece, after it has passed through the vat, to fix the indigo (which it receives from it) fast upon the cloth by exposure to the air, that it may be oxidized, or, to use the expression common amongst dyers, sufficiently aired before it again enters the vat to receive a fresh coating.

On the ends of one line of these top rollers, *f*, *f*, are fixed small pullies, *g*; a universal band, *h*, is wound round each and all of these pullies, connecting them together, so that when the first pulley is put in motion, all the rest are moved by it, and at one uniform speed; or if it is preferred, small bevil wheels may be substituted for the pullies. A single vat may, by this arrangement, be used; the necessity of using two vats together being regulated by the depth of the shade of blue required by the size of the vats, or by the nature of the colors which are printed upon the pieces to be dyed; for instance, where these colors require to be passed through lime water before they are entered into the blue vat, or where the first vat, into which the piece is entered, requires a greater proportion of lime than the second,—then, in both these cases, two vats must be used together; or in case the piece is required to remain only a short time in the lime mixture, previous to its entry into the indigo vat, then a small cistern, *i*, *i*, must be fixed over the vat, as in fig. 3; and the piece having passed once or twice through it over the first or second pair of rollers, continues its progress onwards into the indigo vat.

There is also another advantage in working two vats together;—where a quantity of cloth has been dyed, and the amount of indigo in them consequently reduced, one of these vats may be re-set, and have fresh indigo put into it, while the other is weak, and thus a greater uniformity be obtained, both in the shade of blue, and the speed at which the piece passes through the vats.

When pieces, previously printed, are to be dipped, they are either wound on a roll, or plaited down and laid on a board,

placed over the middle of the vat in which they are to be dyed; immediately over them is a wooden shed or cover, *k*, to keep them dry and protect them from the droppings of the wet pieces, as they pass over the rollers above. The piece is entered into the vat with the unprinted surface to the rollers, and passing under the two first rollers, receives a coating of indigo; it is then drawn out of the vat in the direction of the arrows, to be exposed to the air, by the two rollers in the frame above, corresponding to those in the vat. It then re-enters the vat by the second or next pair of rollers; is again exposed to the air, and so continues to move forward till all the rollers have been passed over in the manner shown in the drawing.

When working two vats together, the piece, after it has run through all the rollers, will be found to have passed from the middle of the first to the middle of the second vat, where it is drawn through a pair of drawing rollers *l*, *l*, and wound on a roll *m*, or plaited down, if preferred; the piece is then taken to be scoured, washed, &c., and prepared for the market.

When a piece has been dyed blue, and it is wished to produce a white object upon it, the pattern is printed either by the block or cylinder, with a color made from bichromate of potash dissolved in water, and thickened as may be required with flower or gum; the strength of this solution being regulated by the depth of blue shade to be discharged. After the piece has been printed with the above color, it is passed through a cistern, filled with a solution of oxalic acid and water; the strength and quantity of the acid, per gallon of water, depending upon the depth of the blue to be discharged. It is however, found, that when a tolerably strong solution is used, (stronger than is actually necessary to produce a white,) a much more perfect white is produced; and that the edges of the solids that form the pattern do not float, bleed, run, or lose their smartness and clearness, as much as they would if a weaker solution were used in this process; however, though the solution of acid be strong, the work in many patterns is not so sufficiently clear as to be considered perfect.

After the piece has passed through this acid liquor, it is entered into lime water, or a weak solution of potash or soda, to clear the whites; and is then washed, finished, &c. Now, the objections to this mode of procuring a white upon a dark blue ground, and the reasons perhaps why it is not more generally adopted, are, first, that the expense of the oxalic acid required is so great, that the same effect may be more economically produced by using a resist; this resist being printed upon the cloth previous to its being dyed in the blue vat; and also the difficulty of procuring a smart and correct impression of the pattern, owing to the flushing and swelling of the discharge.

By this improvement, both these objections are said to be obviated, by subjecting the piece to a very intense heat, suddenly and immediately after it has passed through the oxalic acid solution; for this purpose, a stove, strongly heated by fire, answers the best; but steam heat may be used, by passing the pieces over a row of steam chests, and also by causing several jets of steam from pipes, bored with small holes, to blow upon it: both these plans will answer, but not so effectually as the stove heat; by this plan a very clear and excellent discharge is produced, and with a smaller quantity of oxalic acid than would be otherwise necessary.

III. The *third series* of improvements* are of the invention of Mr. Louis Joseph Wallerand, of Basing-lane, London, and consist in giving shaded stripes of color to woolen, silk, cotton, or other fabrics, by the employment of a peculiar arrangement of machinery, which produces the effect in a more expeditious, economic, and perfect manner, than by the ordinary hand-process. This machine may also be used for dyeing shaded stripes to form a ground upon fabrics intended afterwards to receive a printed pattern.

In Plate I., are several views of the machinery by which the shaded stripes of color are given to the cloth or other fabric. Fig. 1, is a longitudinal elevation of the machine; fig. 2, is a plan or bird's-eye view: and fig. 3, is a transverse ver-

* Patented in Dec., 1844.

tical section, taken in the line 1, 2, of fig. 2. A, is the wooden frame-work, which supports a vat, C, containing the dye-liquor; B, B, is a steam-pipe, running along the bottom of the vat, for heating the dye-liquor; D, and D^1, are brackets, affixed at each end of the machine, and furnished with slots, in which the axes of wooden rollers or cloth-beams J, and J^1, work; E, are a series of bars (made of either wood or metal), which serve as bearings for a series of wheels or rollers, F; and G, are a similar series of bars, placed below the bars E, and are for the purpose of carrying the wheels or rollers, F^1, which correspond in size and position with rollers, F. These bars, E, and G, rest upon cross-pieces at the ends of the vat C.

The drawing represents each pair of bars as carrying eight wheels only, but the number may be increased or diminished as may be thought necessary, according to the nature of the fabric to be dyed.

The upper and lower series of wheels or rollers F, and F^1, are made either of wood or metal, and are mounted loosely on their axles. H, is a roller, covered with felt or other material, and mounted in slotted bearings at the end of the dye-vat C: this roller is intended to take up the color from the vat, and to distribute it upon the surface of the cloth. I, is a lever or handle for raising the roller, H, so that it may come in contact with the fabric. By this means, those parts of the fabric are dyed which would not otherwise have received any color. When a sufficient depth of color is thus obtained, the roller, H, is depressed by means of the lever, I, and thrown out of contact with the cloth. J, and J^1, are cloth beams, upon which the fabric is wound before and after it is passed between the wheels, F. K, and K^1, are wooden vessels at either end of the vat, for the reception of any portion of the dye which may fall from the fabric wound on the beams, J, and J^1. L, is a pipe, furnished with a stop-cock, for the entrance of the steam into the pipe, B; its escape is regulated by the pipe and cock, M. N, N, are cog-wheels, mounted respectively on the axles of the cloth-beams, J, and J^1, for the purpose of receiving motion from any convenient gearing, and conveying it to the

cloth-beams; and O, are cross-pieces, serving to support the fabric while being passed through the machine.

In order to produce shaded stripes by this machine, the fabric, which is first wound upon the beam J^1, is passed from that beam between the upper and lower wheels or rollers, F, and F^1, when it is taken up by the beam, J, to which rotary motion is communicated for that purpose. The fabric, when put in motion, turns the lower wheels, which are partially immersed in the dye-liquor, and also the upper wheels, which press upon the fabric. The lower wheels, F^1, (the peripheries of which are covered with felt or other similar material) by their rotary movement, take up a portion of coloring matter, and deposit it upon the fabric. By this means, the fabric is well charged with color in those parts which pass between and are in contact with the wheels, and on being wound upon the beam, J, the color spreads by capillary attraction, and forms the required gradation of tint. This operation is to be repeated by reversing the motion of the cloth-beams, until the required depth of color is obtained for the stripes. The roller, H, may then be raised, so as to blend the lighter shades of the stripes together, as before mentioned, by giving a tinge of color to the whole surface of the fabric; this may be repeated one or more times, according to the quality of the lightest shade which may be required; but if the shades are intended to be distinct, as will be the case when using two or more colors, as hereafter explained, the roller, H, must not be used.

In order to produce the stripes at greater or less distances apart, it is only necessary to increase or diminish the number of bars, E, and G, and wheels, F, and F^1. The width of the machine may of course be varied, according to the width of the fabric to be dyed.

When fabrics of a thin texture, such as gauze, lace, &c., are to be dyed, the number of rollers may be diminished, as a sufficient quantity of the coloring matter will more quickly be taken up and penetrate the fabric.

In order to ensure a perfect production of the shaded stripes upon both sides of thick fabrics, such as flannels, felted cloth,

&c., a modified arrangement of the above described apparatus (as shown at figs. 4, 5, and 6,) is employed, by which means, a portion of the dye-liquor is deposited in stripes upon the upper surface of the cloth, as well as on the under surface, as above described. Fig. 4, is a longitudinal elevation of this machine; fig. 5, a plan view of the same; and fig. 6, a vertical section, taken in the line 3, 4, of fig. 5. The addition consists of a vessel, Q, containing dye-liquor, which is kept heated by a steam-pipe, R;—S, S, are a series of cocks, attached to the bottom of the vessel, Q, and are intended to supply a limited quantity of dye-liquor to a series of small delivering-wheels or rollers, T, at distances apart equal to the wheels, F. The construction of the cocks, and their attachment with the rollers, will be clearly seen by referring to the enlarged sectional view fig. 6.* U, U, are rods, attached severally at bottom to the plug of each cock, and connected at top to a horizontal bar, V; the forward and backward motion of which causes the cocks to open and close as required, and thus the quantity of liquor supplied to the rollers, T, may be regulated.

The manner of working this machine is as follows:—The fabric is first passed between the upper and lower rollers, F, and F¹, where its under surface receives the dye, which penetrates into the cloth; the cocks are then opened to the extent required, by moving the bar, V; and the fabric, as it passes under the rollers, T, is supplied on its upper surface with the dye-liquor, which flows from the vessel, Q, through the cocks, S, S, on to the rollers, T.

It is sometimes necessary (when operating with certain dark colors) to apply the coloring liquor to the fabric at a boiling heat; in such cases the rollers, T, are displaced, and sponge is applied to the ends of the tubes which descend from the cocks; this sponge, when brought in contact with the fabric, will convey the liquor direct to its surface, and consequently, prevent the possibility of the liquor prematurely cooling, as would be the case if the rollers were employed.

This invention of obtaining stripes of shaded color may be farther modified by the application of two or more dye-

vats, containing different colors. The arrangement of the rollers will be as represented at fig. 7,—the set belonging to one vat, containing (say) a yellow color, being placed so as to intercept the spaces which the rollers in the other vat, containing (say) a red dye, have left on the fabric.

IV. The *fourth series* of improvements* are of the invention of Mr. Hugh Unsworth, of Blackrod, Lancaster, and consist, firstly, in a certain combination or arrangement of mechanism, whereby the various operations of bleaching may be performed in one machine, instead of being separately effected by distinct machines or processes, as hitherto done, and thus producing a better "finish or condition" upon the calicos or other fabrics, and also greatly economizing hand labor. Secondly, in passing the cloth after it has been once dried, again partially through the mangling or calendering portion of the apparatus, and in contact with the wet cloth, in order that the dry cloth may thus be damped or "conditioned," which necessary process in finishing woven goods or fabrics, is usually performed separately by a damping machine. And, lastly, in the application of a drying cylinder to the ordinary mangling or calendering apparatus, thereby rendering that machine much more effective in its operation upon the cloth, in those instances where the improved combination of machinery is employed in mangling only, and not for the finishing process.

In Plate II., fig. 1, represents a side elevation of the improved apparatus, as adapted to operate upon calicos, &c., subsequent to the process of bleaching.† and fig. 2, represents a similar view in section, taken vertically through the middle of the machine.

The main framing or standard of the machine *a*, *a*, *b*, *b*, support or carry ordinary mangling or calendering bowls or rollers, *c*, *c*, *c*, *c*, (composed as usual, some of brass or metal, and others of paper or cotton, as required,) bearing in steps or pedestals, *d*, *d*, *d*, *d*, and also a large drying cylinder, *e*, heated by steam through its axis, supplied by the pipe *f*, or other-

* Patented in August, 1840.

† See chapter I. Part II.

wise; other auxiliary drying cylinders, *g*, *g*, *g*, *g*, are also provided and suitably furnished with tension or guide rollers, *h*, *h*, *h*, *h*, when the drying surface of the cylinder, *e*, is not found sufficient, as in the mangling process only. The machine is also provided with heavy weighted leverage, *i*, *i*, and connecting links, *k*, *k*, for the purpose of increasing the pressure of the mangling cylinders, *c*, *c*, and dispelling the greater portion of wetness in the first instance, as the cloth enters the machine, passing over the stretching or distending bars, *l*, *l*, *l*. There is also the ordinary similarly weighted leverage, *m*, *m*, applied to the upper calendering rollers, *c*, *c*, and also the usual lifting bar, *n*, *n*, with its rack and pinion, *o*, *o*, to be worked by a winch handle, for raising the two upper rollers, *c*, *c*, when necessary, by means of links or rods, *p*, *p*.

The operation of the machine is as follows:—the wet cloth, as it comes from the squeezers after bleaching, or any other wet process, is placed upon a scray or table, and first guided by the hands of the attendant over and under the stretching rails, *l*, *l*, *l*, and passed between the two lower mangling rollers, *c*, *c*, where great pressure being applied, as before stated, it is ready to proceed immediately around the drying cylinder, *e*, when it may be only partially dried, and passing onwards (in the direction of the arrow,) is submitted to the upper calendering cylinders, *c*, *c*, and over the other drying cylinders, *g*, *g*, *g*, *g*, as shewn in the drawing, when the dried cloth is again passed into the machine at the back, proceeding from the surface of the lowest drying cylinder, and thence through the calendering bowls, *c*, *c*, a second time, but now in contact with the wet, or only partially dried cloth; thus receiving the operation of damping by such contact, instead of being separately damped by another machine, as heretofore done; this damping and finishing operation, being thus much better performed, and the "condition" and "finish" of the cloth materially improved. After this operation, it is wound upon a roller at *q*, by a strap, *r*, passing around the pullies, *s*, *s*, or in any other convenient manner. If thought desirable, an ordinary stretching cylinder may be employed in this machinery, as shewn by dots in fig. 2, in place of the rails, *l*, *l*.

V. The *fifth series* of improvements* are of the invention of Mr. John Keely, of Nottingham, and Mr. Alexander Alliott, of Lenton, and consist in an improved apparatus for drying or freeing liquid or moisture, from cotton, silk, wool, &c., and also in stretching the goods.

In Plate III., fig. 1, represents, in partial sectional elevation, a machine for drying goods solely, or freeing them from liquid or moisture. A, A, is the frame-work of the machine; B, a vertical shaft, which turns in a socket, *a*, in the bottom bridge, *b*, and carries at top a friction-cone, *c*, by which a rotary motion is given to it, in the manner to be hereafter more fully explained. C, C, is a drum, of two concentric compartments, *d*, *d*, *e*, *e*, of the shape shown in the drawing, which is fitted loosely on the shaft, B, and rests, when not in motion, on two conical projections, *f*, *g*, turned upon the shaft: both compartments have one common bottom of metal, and are formed at the sides each of a continuous length of tinned iron wire, wound in a series of circles, at small distances apart, and connected transversely by slips of metal, soldered thereto. The top or cover of the inner compartment, *d*, *d*, is secured by nuts and screws to a ring of angle-iron, which binds the wire sides together, at top; but that of the outer compartment, *e*, *e*, in which alone the goods to be dried are placed, is made to lift off, in order to introduce and remove the goods, and has a rim, both on its outer and inner periphery; so that, when fixed in its place, the inner rim presses against the outside of the inner compartment, and the outer rim overlaps the sides of the outer compartment itself. When the machine is at work, the cover of the outer compartment is further secured in its place by bolts or pins (not seen in the drawing). The sides of the inner compartment, *d*, *d*, are connected to the bottom by prolonging the transverse slips of metal which connect the circles of wire, and rivetting and soldering them to the plates. The wire sides of the outer compartment are bound together at top by a ring of angle-iron, to which they are rivetted and soldered, and are connected to

* Patented in March, 1843.

the bottom plate by turning up the plate over the sides, and soldering and rivetting, as before. D, D, is a governor, suspended within the inner compartment, *d*, *d*, of the drum, C, C; the two weighted arms, *h*, *h*, being loosely affixed at their elbows to two studs in the top plate of the drum, so as to turn freely thereon, and resting, by their upper ends, on a collar, *i*, projecting from the shaft. E, E, is an outer case, which surrounds the whole of the drum, except at top, and is intended for the reception of the water driven off from the goods, but is fixed, not to the drum, but to the framework, A, A. At *y*, there is a tap for drawing off the water, and in the bottom an orifice for the insertion of a pipe to admit hot air. When rotary motion is given to the vertical shaft, B, it carries round with it the drum; and, in proportion to the velocity of the motion, there is a centrifugal tendency imparted to the liquid particles contained in the goods (which is the useful effect desired to be produced by the machine); but, as the same centrifugal tendency in the parts of the machine would, in case of any unequal distribution of the weight, cause, if not counteracted, an injurious strain on the central shaft, B, and might cause, at the high velocities necessary for drying goods quickly, an actual disruption of the machine (and this difficulty is further increased when the weight of the goods happens to be not quite equally distributed over the drum), the governor, D, D, has been introduced to prevent such consequences. The arms of the governor expand as the speed of the shaft increases, and gradually raise the drum, C, C, from off its seat on the conical supports, *f*, *g*; and thus the drum is left free to adjust itself according to its natural gravitating tendencies, so as to bring the centre of gravity in uniform coincidence with the centre of rotation. The drum is gimbled to the shaft in the manner shown at *z*, fig. 1, which allows of its moving in any direction. To prevent the drum from rising too suddenly, there is a spiral spring, *k*, affixed to the shaft, immediately above the conical support, *g*. For still farther maintaining the drum in a state of equilibrium, it is encircled at the middle by a hollow ring or girdle, F, F, which is about half filled with water,

or other suitable fluid; as this ring rotates, should the weight of goods incline to preponderate at any part, the weight of water, getting to the opposite side, serves more or less to prevent and counteract such preponderance. The equilibrating effect of this ring is increased, if the interior is divided into two or more channels. G, is a pipe by which steam or hot air can be introduced into the centre of the drum, when it is desired by these means to accelerate the drying of the goods, the bottom of the drum being perforated at the centre with a number of holes, to admit the same. The rotary action of the shaft, B, is obtained in the following manner:—I, is a disc, affixed to the end of a shaft, which disc is beveled off near its periphery, to correspond, at that part, with the surface of the cone *c*, and shaft, B, so that, when made to revolve in a horizontal direction, it shall cause the cone, *c*, and shaft, B, to revolve in a vertical direction. L^1, is a cone, affixed to the end of the shaft, K^1; and L^2, another cone, of the same dimensions, but placed with its base opposite the apex of the other, and is affixed to a shaft, K^2, communicating immediately with the first mover. M, is the belt which connects the two cones, and by the unwinding of which from the larger end of one cone upon the smaller end of the other, or *vice versâ*, with the help of a guide, in the known manner of working such alternate cones, motion is communicated to the shaft, K^1, and is retarded, or accelerated, or kept at one constant rate, according as may be desired. N, is the pulley to which the power of the engine is directly applied. Instead of one friction disc only (I,) being made use of, two such discs may be employed, if found needful, with an additional friction cone between them, the better to equalize the action of the rubbing parts; but in that case the additional disc and cone must turn loosely in their own bearings. Instead also of the vertical shaft B, being stepped at bottom, in the manner represented in fig. 1, the arrangement shown in fig. 2, may be adopted. The bottom of the shaft is surrounded, immediately above the step, with a loose ring, *m*, and that ring with a quantity of small shot, or other granulated substance, the whole being enclosed in a box, *n*, the bottom of which forms

the step. In the top of this box there is an opening, into which a collar, *p*, on the shaft, dips, when the machine is at rest; and when the drum, C, is raised by the action of the governor, D, the collar is also raised out of its place, when the shot, yielding to the sideward movement of the shaft, enables it to adjust itself to any change in the centre of gravity.

Another machine for stretching, and also for drying, is represented at figs. 3, and 4; fig. 3, being a side elevation, and fig. 4, a cross section of the machine. A, is the foundation plate. B, (see fig. 4,) is an axis, which turns in bearings in the front part of the standards, *c*, *c*. The parts a^1, a^2, a^3, are plain; the parts *b*, *b*, are a little raised above the others, and are cut, the one with a left-handed, and the other with a right-handed screw upon it. D, D, D, D, are a number of wire hoops, over which the cloth or other material is to be stretched, each consisting of four, five, or more rings of tinned iron wire, secured together by transverse slips of metal (similar to the wire sides of the drum before described), each of which is attached by radial arms to a separate collar, which slides on the smooth central part a^2, of the, axis, B. The hoops, when brought together, have the appearance of one continuous drum, but are free to separate a little in the course of the working of the machine. E, E, are two ventilators, of the form shown separately at fig. 5; these ventilators are attached to moveable collars, with female screws inside, which work on the screwed parts, *b*, *b*, of the axis, B, and may be brought up more or less close to the series of hoops. On the rims of these ventilators there are rows of pins, to which the selvages of the cloth or other article to be stretched may be secured. In the centre of each ventilator an orifice is left, for the introduction, by means of a moveable pipe or pipes, F, F, of a supply of steam or hot air into the interior of the hoops, round which the goods are stretched. G, G, are rings, of the form shown on an enlarged scale at fig. 6, which, when the cloth or other article has been wound round the hoops, and secured to the pins on the peripheries of the ventilators, fit upon these peripheries, and interlock with and support the pins. It will now be seen, that if rotary motion is communi-

cated to the axis B, and the drum is secured from turning by any convenient means, the ventilators will each have a tendency to move in an outward direction from each other, and thus cause a continued stretching of the goods laterally. To keep the goods at the degree of tension required, and prevent the ventilators from returning, there are two coupling pieces, each furnished on their inner surface with a small stud, which slides in a groove cut on each of the screwed parts, *b*, *b*, of the shaft, B, and having projecting sides, which take into corresponding recesses formed on the collars of the ventilators, are pushed forward. But, besides being stretched laterally, the goods may require to be stretched longitudinally, and for this purpose the machine is provided with the additional parts next to be described. K^1, K^2, and K^3, are three cross rods or poles, fixed between the stops of the standards, C, C, (see fig. 3,) in a triangular position, as regards one another. L^1, L^2, are two bars which turn freely in bearings in the back of the standards, C, C, and carry each two rollers, one at either end, which are connected by an endless band, armed with a number of small projecting teeth. M, is a roller, which turns on an axis between the standards, C, C. N, N, are two longitudinal rods, which turn freely in bearings in the back of the standards, C, C, at one end, and in the shorter standards, O, O, at the other end, and are cut with a thread upon them of a progressively decreasing pitch from C, C, towards O, O. P, P, are tubes, which slide on the rods, N, N, having a catch, *o*, projecting from the inside, which takes into the threads on these rods.* R, S, are two additional rollers, which turn in bearings raised upon the top of the sliding tubes, P, P, and are connected together at their ends by bands, in the manner shown in the figure. The roller R, has a number of bristles affixed to it, for the purpose of brushing the goods as they pass in contact with it. The drum or cylinder of hoops, D, before described, is connected with the roller, M, by wheel-gearing, in the manner shown in the drawings, and these

* When we say, P, P, or, O, O, and only one letter is shown in the figure, we, of course, mean to be understood as referring to both sides of the machine.

again with the longitudinal shafts, N, N, which carry the other rollers, R, S, by means of bevil-wheel gearing. The distance between the roller, M, and the rollers, R, S, must be regulated at starting, according to the degree of stretching required to be given to the goods. To the roller M, a tacking-piece must be permanently fixed, to which the goods may be attached; this tacking-piece must be equal in length to a line carried from the bottom of the roller, M, round the roller, S, and back to the hoop-cylinder, D.

The following is the operation of the entire machine:—The wheels being first thrown out of gear, by means of two small levers, *l*, *l*, attached to the inner ends of the longitudinal rods, N, N, (see fig. 3); one end of the goods is carried over the fixed poles, K^1, K^2, and K^3, in the manner shewn, and thence down the face of the endless roller-bands, L^1, L^2, the teeth of which catch into the selvages of the goods, and serve to keep them evenly distended in the direction of their width. The goods pass from the endless bands to the roller, M, and are then joined to the tacking-piece on the roller, upon which they are then wound, by means of the winch-handle attached to its axis. The bevil-wheels are then put into gear again. The endless band-rollers, L^1, and L^2, are brought into a horizontal position, the cloth unwound from the roller M, and carried under and over the roller S, whence it is carried back, in a direct line, to the drying cylinder of hoops, D, and in its progress comes into contact with the brushes on the face of the cylinder, R, and is again caught at the selvages by the teeth of the endless bands, L^1, L^2. By turning the screw-threaded horizontal rods, N, N, by means of the winch-handles at the ends, any required degree of tension may be given to the goods; for, according as these rods are turned in one direction or the other, the sliding-tubes, P, P, are caused to recede or advance, and the rollers, R, S, along with them. After the goods have been all wound on to the hooped cylinder D, the wheels are thrown out of gear, and the cylinder D, is made to revolve by itself. When hot air is used to assist the drying, and the goods are put into the machine in a damp state, the hot air should not be introduced till after

the principal part of the moisture has been driven off by the centifrugal process. For the purpose of better maintaining the equilibrium of the machine, a ring or girdle, T, containing water, or any other suitable fluid, similar to that before described, is introduced inside the hoops, in the manner shewn at fig. 4.; the goods, being wound on the drum or cylinder, D, are ready to be stretched laterally, as before described. The drum may then be disconnected from the intermediate wheel, X, of the gearing, and a swift rotary motion being given to its axis, the liquid particles contained in the goods will be driven off by the centrifugal action, as before described under the first head of the improvements. Although the drum, D, is shewn in the drawings in a horizontal position, it will be better, where drying is the chief object, to place it in an upright position, and then connect it with driving machinery, such as is described under the first head of the improvements. The outer cylinder, in which the drum is encased, and which should be some inches larger in diameter, has a pipe at the bottom, for the purpose of admitting steam, and another for the admission of heated air. It is further provided with a tap at bottom, for drawing off the liquid which collects there. After the greater part of the water has been thrown off by the centrifugal action, a supply of steam is admitted, for the purpose of heating the goods previous to the admission of the heated air.

This machine is being very generally adopted throughout Great Britain. Indeed, it is rapidly superseding every other machine for drying cotton goods.

CHAPTER III.

RECENT INVENTIONS AND IMPROVEMENTS IN DYEING AND CALICO-PRINTING PROCESSES.

BLOCK-PRINTING, HAND AND POWER.

I. THE *first series* of improvements,* are of the invention of Augustus Applegarth, of Crayford, Kent, and consist in certain contrivances and machinery for facilitating *block-printing*.

In Plates III. and IV., Fig. 1, is the third side of a machine for printing six colors.

Fig. 2, is the opposite side of the machine.

Fig. 3, is an end elevation of the same.

Fig. 4, is a plan of the upper parts thereof. The same letters refer to the similar parts in all the figures. A, A, is the cast-iron frame; B, B, the moveable frames or heads to which the block-tables, C, C, are attached by means of hinges, which permit the block-tables to be turned over when the blocks require brushing, &c. D, D, are the blocks which are cut, cast, coppered, pinned, or engraved in the usual manner. They are fixed to the block-tables by means of screws or T headed holders, as further explained in the diagrams, figs. 5, 6, 7, and 8. E, is the impression-table, which is made of cast-iron or stone, and which should be flat, solid, and heavy, in order to receive the blow or impression. At each end of the impression-table is a roller, which serves to guide the cloth to and from the impression-table. F, F, are the rubber-carriages, which support the rubbers, G, G, in the notches; the under surface of the rubber-carriages is made with inclined planes, so that when the carriages advance they lift the rubbers one

* Patented in November, 1836.

quarter of an inch. H, H, are the hammers or mauls which give the impressing blow to the block-tables, C, C. The hammers are fixed to the wrought-iron shafts, I, I, by means of the sockets and binding-screws, which permit them to be adjusted so as to strike the block-tables simultaneously. K, the feeding-drum which advances the printing-cloth and the material to be printed, and its periphery should contain or be divisible into any certain number of spaces, each equal to the set of the blocks or the quantity of cloth which each block prints at one impression in this machine: it contains fifteen spaces of three inches each, which is the set of the pattern here shewn. The feeding-drum is furnished with a wheel, L, having ninety teeth, or half-inch pitch, and it has also fifteen stop-pins accurately pitched, which regulate and govern the advance or feeding in of the cloth and the material to be printed, and upon the correctness of which the joining of the pattern depends. M, is a double pinion, or two pinions fixed upon the same axes: the small pinion has twenty-four teeth, and is always in gear with the wheel, L: the larger pinion has forty-eight teeth, and is furnished with four arms: it is occasionally driven by the toothed segment, N, which is furnished with a curved wiper, which acts against the arms of the larger pinion, M. O, is a segment within the frame, A, which occasionally comes in contact with the small wheel or roller, P. The segment, O, and the roller, P, are made of wood, and are covered with coarse cloth, so as to produce motion by the pressure of their surfaces against each other without teeth. Upon the spindle of P, two band-pulleys are fixed, which occasionally give a backward and forward motion to the rubber-carriages, F, F, by means of their catgut bands. Q, is another wheel or roller clothed as P, against which the clothed segment, O, acts as soon as it has left P. Upon the axis of the roller, Q, is a band-pulley, which carries a crossed band to another pulley fixed upon the spindle, P, whereby the motion of the spindle of P, and its band-pulleys is reversed, and the rubber-carriages are drawn back. R, R, are small grooved pulleys which guide the catgut bands. S, is a roller which binds or confines the printing-cloth to the feeding-drum, K.

T, is a similar roller, which binds the oil-skin and the material to be printed in like manner to the feeding-drum, K, so that they are conveyed by the feeding-drum without any drag or stoppage. V, is a pall which acts against the division-pins of the feeding-drum wheel, L. The printing-cloth or blanket is made endless, and passes from the feeding-drum across the impression-table, and over the roller at the leaving end of the impression-table, turning under the impression-table to the roller, S, and the drum, L. The oil-skin is also made endless, and passes over the roller, T, to the feeding-drum, then over the roller at the entering end of the impression-table, across the table over the roller at the leaving end of the table, and away from the machine, in the manner shewn in the diagram, fig. 9. The cloth, silk, or material to be printed, is first supplied from a roller in the usual manner. The cloth, &c., is conveyed to the impression-table in the following manner:—The toothed segment, N, moves the pinions, M, one quarter of their circumference, which causes the feeding-drum to advance as much as is equal to one set or impression of the pattern cut upon the blocks, and a little more, so that the division-pin may pass the end of the pall, V, just so much as to admit it to fall behind the pin, when the elasticity of the cloth, &c., will draw the drum and wheel a little back, until the pall stops the pin, and holds the drum and the materials upon it firm and steady during the impression. W, W, are wrought-iron bars moving up and down in guides; they are connected with the moveable heads, B, B, and are furnished with friction pulleys, V, V, against which the cams act, and occasionally raise and depress the heads, B, B, and the blocks: their brass guides are seen in fig. 1. X, X, are the depresssing cams. Y, Y, are the lifting cams; they are fixed on the spindles of the wheels. Z, Z, are counter-weights, and their levers, they serve to counterpoise the bars, W, W, and the heads, B, B, and thus steady and soften the up-and-down motion. The wheels, *q*, *q*, *q*, are in gear with each other, and have seventy-two teeth of one inch pitch. *a*, *a*, are cams, which occasionally depress the pulleys and levers, *b*, *b*, which are connected with the rods, *c*, *c*, the upper-ends

of which are made to loop over, and embrace the arms, *d*, *d*, of the hammer-shafts, I, I. When the full part of the cams, *a*, *a*, depress the levers, *b*, *b*, the rods, *c*, *c*, draw the arms, *d*, *d*, in a downward direction, and raise the hammers to the position shewn in fig. 1, and they are detained in this position by means of the hooked-levers, *e*, *e*, which move on the pins, *f*, *f*. On the cams, *a*, *a*, are detaching pins, *g*, *g*, which occasionally raise the lower ends of the hooked-levers, *e*, *e*, and cause them to let go the arms, *d*, *d*, of the hammer-shafts, I, I, when the hammers fall by their own gravity, and give the impressing blow upon the block-tables, C, C, C. The force of the hammers may be increased by circular weights, having a central hole to fit on the head of the hammer, one of such weights is seen in fig. 1. *h*, *h*, are counter-weights, which overbalance the rods, *c*, *c*, and the levers, *b*, *b*, and thus keep the looped ends of the rods clear of the arms, *d*, *d*, when they rise on the fall of the hammers.

The blocks are supplied with color, in the following manner: *i*, *i*, is the sieve-frame, containing the sieves or color surfaces, *j*, *j*; they are made of waterproof cloth, or any suitable material that will not suffer the color to pass through; *k*, *k*, *k*, are brushes to spread or distribute the color, called teering-brushes, they are attached to the cross-bar, *l*, which is furnished with a small friction-roller, *m*, against which the inclined planes, *n*, *n*, act, as the sieve-frame advances, and by which means the brushes can be lifted clear of the ends of the sieves, and sieve-frame, and the length of their contact with the sieves determined. To assist the action of the teering-brushes, a cross-bar of wood or iron, padded with a blanket, and covered with a piece of oil-silk, may be fixed under the sieves to the side-bars upon which the sieve-frame slides, which will bear the sieves up as they slide between the cross pad and the brushes, and better enable the brushes to teer out and obliterate the impression of the blocks upon the sieves. *o*, is a catgut band-pulley, which revolves upon an axis fixed to the frame, and motion is occasionally given to it by the clothed segments, *p*, and *p**, which are fixed to the wheels, *q*, *q*, by acting against the clothed wheel, *r*, which is

fixed upon the axis of *o*, which is furnished with two arms, *s*, and *s**, against which the pins, *t*, *t*,* of the clothed segment act, and thus ensure the starting of the band-pulley, and the sieves at the proper times. The action of the machine is as follows:—The cam, Y, having raised the moveable heads, B, B, and the blocks, from the impression-table, E, as shown in fig. 1, the segment, *p*, is shown with its starting-pin in contact with the arm, *s*, of the wheel, *r*, of the band-pulley, *o*, which as it moves, will draw the sieve-frame, *i*, *i*, and its sieves, under the blocks with the colored surface of the sieves, about one inch below the engraved surface of the blocks. The cams, X, X, will then in their progress, press against the lower friction pulleys of the rods, W, W, and depress them, and the heads, B, B, with the block-tables and blocks, nearly one inch, so as to bring the engraved surfaces of the blocks slightly into contact with the color upon the sieves, but, by no means to press upon the sieves themselves. The segment, O, will then come in contact with the small friction-wheel, P, and cause it to revolve with its band-pulleys, which will, by means of their catgut bands, draw the rubber-carriages, F, F, forward. The under sides of the rubber-carriages are furnished with small inclined planes, which as they advance, raise them and cause the elastic surfaces of the rubbers to press against the under side of the sieves, and thus as the rubbers move, they complete the contact of the colored sieves with the engraved blocks, whereby a proper portion of color is transferred from one to the other, the action of the machine continuing. The segment, O, will next act against the small wheel, Q, which by means of its crossed band will reverse the motion of the wheel, P, and cause its band-pulleys to draw the rubber-carriages back into their former position. The segment, *p**, will then act against the arm, *s**, of the wheel, *r*, and thus cause the band-pulley, *o*, to draw the sieve-frame back to its former position, as seen in figs. 3 and 4. The detaching-pins will then disengage the hooked-levers from the arms on the hammer-shafts, and the blow, or impression, will take place, and thus each block will print cloth equal to its own size, or set, at one revolution of the wheels,

q, *q*. The full part of the depressing cams, X, X, having previously caused the heads, B, B, and the blocks to descend upon the material on the impression-table.

Fig. 5, represents the back of a printing-block, with three iron strengthening plates let into the wood, which have gaps in them to receive the T, holding-screws and nuts, which are seen in fig. 6, fixing the block, D, to the block-table, C.

Figs. 6, and 7, show a convenient method of connecting the block-tables, C, with the moveable heads, B, B, before described. *a*, *a*, are flat-plates of wrought iron, one-eighth of an inch thick, which are firmly screwed to the ends of the block-tables. *b*, *b*, are pins rivetted into the hinges, *c*, *c*, and screwed to fit the thumb-nuts, *d*, *d*; the holes in the plates, *a*, *a*, are larger than the pins, *b*, *b*, to admit a little motion for adjusting the blocks. The hinges, *c*, *c*, are firmly fixed at one end to the moveable-heads by the screws, *e*, *e*, at the other end they are held by the thumb-screws, *f*, *f*.

Fig. 8, is a diagram of the moveable-heads and block-tables, with one of the tables reversed. In order to bring the face of the block in view, one set of the hammers is thrown back out of the way, which is done by partly unscrewing the binding-screw, in the socket of the arm, *d*, which then permits the hammer-shaft to be moved round.

Fig. 9, is a diagram in which instead of a rubber, as before described, a roller is used to make the contact between the sieve, or color-surface, and the block. B, is part of the moveable head. C, the block-table. *i*, *i*, part of the sieve-frame, and D, is the block which is retained near the color surface, but not in contact with it. R, is the roller, which may be made of wood, or of brass tube, and is covered with elastic composition, made of molasses and glue, commonly used in letter-press printing machines, and it is then covered with water-proof cloth, the roller revolves freely upon its axis, and may be made to press up against the sieve by counter-weights, or springs. The contact of the color-surface and block, takes place only where the roller raises the sieve as it passes backward and forward, and this modification of the coloring apparatus is preferable, when the blocks are very

finely cut, or coppered. A slight degree of elasticity is required in the sieve, which may be given either by lacing the sieve to the sieve-frame, with India-rubber bobbin, or by attaching it with fine spiral springs, or by any other convenient method.

Fig. 10, shows a rubber detached from the machine before described. It consists of a cast-iron trough, holding a flexible or yielding waterproof tube, nearly filled with water, or any other fluid that will not permeate the tube, and securely closed at either end, so as perfectly to retain the enclosed fluid. The tube can be securely retained in its position in the trough, by enclosing both in a covering of thin linen cloth sowed together, and the firmness of its action or touch against the sieve, can be easily regulated by tying the ends more or less, so as either to increase or diminish its capacity, and consequent resistance, without either removing or injecting more fluid.

In figs. 1, 2, 3, and 4, the colors are supposed to be supplied by two boys, one standing on each side of the sieve-frame, as the teering-brushes, which are attached to the bar, *l*, only spread or distribute the color, but do not supply it.

Fig. 11, shows a method by which the teering-brushes may themselves supply the color to the sieves. B, is the moveable head, and its block. *i*, *i*, is the sieve-frame. When the sieve-frame has run in under the blocks to supply them with color, the bar *l*, and its teering-brushes, may be lowered down by means of its friction-pulley, *m*, and the inclined plane, *z*, brought into contact with the rollers, *s*, *s*, in the color-boxes, *t*, *t*; the quantity of color on the roller, *s*, can be regulated by the padded straight-edge, *v*, which may be adjusted, and held by the screws, *x*, *x*, and the color-roller, *s*. should have a very slow motion around their axes, to renew the color taken from it by the teering-brushes. In this case, the pad beneath the teering-brushes may be removed, and double sets of brushes, as shown in the drawing, may be used if required.

Fig. 12, is a side view of an apparatus for applying the color to a hand-block, such as is used by block-printers.

Fig. 13, is an end view of the same.

Fig. 14, is a plan thereof. The same letters refer to the similar parts in each figure. A, is the cast-iron frame. B, the block. C, the sieve or color surface. D, the teering-brush, which is fixed to the cross-bar, E, which serves also to connect the side standards, F, F, the under sides of which are furnished with projections which enter into the slide-passage, Z, made between the frame and the top bar, G, G. The side standards, F, F, are further connected by a stretcher-bar or rod. H, is the color-trough; I, the roller, the color on which is regulated by the padded straight-edge. K, L, is a padded board, which also moves freely in the slide-passage, Z, and serves to support the sieve when the brushes pass over it. M, is the contact-rubber, made as described in fig. 10, and it also moves or slides freely in the passage, Z. N, N, are small grooved pulleys, which guide the catgut bands. O, is a segment covered with cloth, and fixed upon the spindle, P. As it revolves it moves the clothed wheel, Q, and causes it and its spindle, and the fly-pulleys, R, R, fixed upon the spindle, to revolve, when it draws the standards, F, F, and the cross-bar, E, with its teering-brush, along the sieve in the direction of the slide passage, Z, and thus imparts the color to the surface of the sieve, the block being then used by the printer in impressing the material. As the standards advance, their projections, which slide in the passage, Z, come in contact with the ends of the pad, L, and push it along the slide, the teering-brushes being then in contact with the upper surface of the sieve, and the pad, which is directly beneath them, in contact with the under surface of the sieve, and thus the sieve receives its color, and the mark or impression made by the pattern of the block is effectually obliterated or teered out. When the segment, O, has left the roller, Q, it acts against the reversing-roller, S, which is fixed to its spindle, as is also a small fly-pulley, T, which carries a catgut band to V, which is similar to the pulley upon the spindle R, and thus the motion of the fly-pulley, R, becomes reversed, which returns the standards, F, F, and the teering-brushes, back to their situation over the color-roller. The pad, L, is also drawn back by the standards, E, E, by means of the spring-catches or hooks,

a, which move upon pins, *p*, fixed to the standards, and they act upon the small projecting studs, *b*, *b*, at the ends of the pad, and thus hold it during the return motion, until the pad is stopped by the stop-pins, *c*, *c*, fixed to the frame, when the spring-catches rise up the bevel-edge of the stud, *b*, and leave the pad in its first situation, as shown in fig. 12. In order that the spring-catches may not, during the advance, strike the pad-studs, *b*, and push the pad before it, the catgut bands which draw the standards are attached to eyes fixed in the catches, which raise their ends over the studs, *b*, *b*, so that the pad is only acted upon by the spring-catches during the return. The spring-catch is shown by the side of fig. 12, on an enlarged scale. W, is also a clothed roller, having upon its spindle a fly-pulley, which carries a crossed-band to a similar fly-pulley upon the spindle of X, which draws the contact-rubber, M, backward and forward in the same manner as the standards just described, the rubber having less distance to travel than the brushes, its fly-pulleys, X, X, may be proportionably smaller.

In connecting the coloring-machine with the driving power, it would be convenient so to arrange it that the printer may stop and start it as he requires, by placing his foot upon a treadle or treadles connected with the clutch or driving-pulleys.

Fig. 15, shows an arrangement of the sieves, in which they enter sideways under the blocks. B, is the moveable head. C, C, are the block-tables. D, D, are the blocks, as before described. *i*, *i*, the sieve-frames which move towards each other until they meet in the centre between the blocks, when the color is applied to the blocks in the manner before described, and the backward and forward motion of the sieve-frame may also be produced by segments and band-pullies. The feeding in of the cloth, and the mode of giving the impression, is likewise made in the same manner as hereinbefore explained. In this form of machine, and in that described in figs. 1 and 2, the material to be printed is supplied to the feeding-drum from a roller, having a quantity of the material around it, in the ordinary manner of copper-plate presses and

cylinder-machines, and after the material has left the machine printed, it is carried away by the common methods over and under guide-rollers, the position of which, as well as of the course of the material, must depend upon the situation where the machine is worked or placed. The course of the printing-cloth or impression-blanket is shown in figs. 1 and 2. It is to be observed, that when an endless oil-silk is used to print upon the superfluous color which has passed through the material in printing, it must be wiped off of the oil-silk, dried by rubbing it with a dry cloth, before it returns to the machine.

II. The *second series* of improvements* in block-printing, are of the invention of Mr. Robert Sandiford, of Tottington, Lancaster, and consist, firstly, in the peculiar construction of the block from which the impressions are made upon calicos, muslins, silks, paper, and all other fabrics in the ordinary art of block-printing by hand. The particular feature of novelty in the construction of these printing blocks, is effected by making a light framework of wood, metal, or other suitable material, carry the design or pattern to be printed, instead of having it formed by "cutting and brassing" upon a solid block.

It is well known to practical block-printers, that hitherto printing blocks have been exceedingly limited in their dimensions, owing to any increase from the usual size, making them much too heavy for the workmen to use; and also that their liability to cast or warp would be increased, whereas, even in their present small size, they are very subject to split and lose the evenness of their surface.

These objections to the use of large blocks, are completely overcome by means of this invention. By the use of light open frames, instead of solid blocks, the workman will be enabled also to avail himself of many other practical advantages; for instance, the framework, or bed, is a permanent block, upon the various rails of which, can be screwed or otherwise fixed patterns or designs, and which may be re-

* Patented in June, 1838.

moved to be replaced by others with great facility, and also make use of the "faces" or designs taken from old blocks; and by dividing or cutting them up, Mr. Sandiford informs us that he is enabled to select any parts or portions of such designs, and form a whole or new pattern by any desired arrangement of the dissected parts upon the frames. Without enlarging further upon the peculiar advantages of these improvements we will now proceed to refer to the drawing, in order that the practical effects of the same may be more easily understood.

Plate V., fig. 1, represents a light framework of wood, which is substituted in place of the solid block in common hand printing: this frame consists of plain light rails, *a*, *a*, *a*, *a*, firmly secured together; but it is evident it may be constructed in any other form, or of any other light material, as light metal tubing, or any other suitable substance. Upon this frame thin slips of wood, or other material, as fig. 2, having the pattern or design intended to be printed, formed upon them, are to be screwed upon the frames in separate rows, or any other order, that shall produce the print required; as, for instance, if the goods to be printed are to be handkerchiefs or shawls, for which these improvements are particularly adapted, then the frame will have the centre or filling made up as at *b*, *b*, in fig. 3, and have a complete border pattern also fixed upon the frame, as at *c*, *c*, and with one dip of the block produce the complete handkerchief at one impression; fig. 4, shows a whole handkerchief printed in one color by a single impression of the block, and the complete pattern made up of small slips properly arranged upon the frame, *a*, *a*, *a*, *a*, but which, by themselves, would only print strips. In fig. 5, *d*, *d*, represents the border pattern, and *e*, *e*, the centre or filling up pattern. In most cases, that is, in handkerchiefs of two feet, or two feet six inches square, the workman, by these means, is enabled to print an entire handkerchief; but where the shawl requires to be larger, or four times that size, it must be produced by four points, arranged upon the frame as in fig. 6, and the block turned at every impression until the whole is completed. It will also be very evident to block

printers, that where the impressions to be made are for garment cloths, and not for handkerchiefs, the patterns must be suitably arranged upon the frames, and which needs no further explanation, as a printer will be aware that he may make any alterations with these improvements as the particular arrangement of the pattern and colors may require; fig. 7, is a section taken through the frame and pattern.

Secondly, in printing piece goods in the entire length, these improvements possess considerable advantages, as an entire piece, by the use of these frames carrying the design to be printed, may be completed in a few minutes in three colors as follows:—Place three ordinary printing tables, end to end, in one length, and with three printers, each having his own block or frame of the same size square as the width of the piece of goods, and also furnished with his own sieve of color, the first printer, with one dip, puts on his object or print in the ground color, and the cloth immediately is passed to the second or third printers to receive their shades or colors upon the same ground; and thus the whole piece is successively printed in three or more colors from end to end. In order to complete this rapid operation of block-printing with the best effect, the printed cloths must pass over a cylinder or drum, placed at the end of the last table, and heated by steam, or otherwise.

Lastly, Mr. Sandiford proposes a further improved arrangement of the blocks connected with the art of block-printing, by a print or impression such as is represented in fig. 8. This is accomplished by having the print, *f*, *f*, *f*, and the objects, *g*, *g*, *g*, and *h*, *h*, *h*, so arranged upon the block, that by one impression of the same, three or any number of colors may be printed from them, and thus distinct objects or designs, and in different colors, may be printed at once. The sieve of color upon which the block or frame is to be dipped before printing, must be made in three or more compartments, having partitions, and each containing its own separate color; and thus it will be evident that the pattern may be completed by three impressions of the same block, and by one printer

advancing one-third the size of the frame at every impression, and thus completing the pattern as shown at fig. 9.

There is another practical advantage arising from the use of these open frames and patterns in block-printing, which will also be readily observed by persons conversant with the art. The openings or interstices, *i*, *i*, *i*, *i*, see fig. 3, between the frame of the block, and the patterns or devices upon the slips, *b*, *b*, will prevent any air from being confined between the face of the block and the sieve cloth, when the block is dipped to receive the color, and thereby the block will "furnish" with color, without being interrupted by confined air-bubbles, which frequently occur, and prevent the color from being evenly received by the block.

III. The *third series* of improvements* in block-printing, are of the invention of Mr. James Hudson, of Gale, near Rochdale, and consist in a travelling endless web, moved by power, which, by passing progressively from the color vat over the diaphragm, brings forward continuously a uniform supply of the colored paste for the workman's block. In the process of block-printing, as commonly practised, a circular sieve with a wooden hoop is used, which sieve rests upon an oil cloth extended over, and nailed to, a wooden hoop, and which floats in a cistern or tub, containing a viscid fluid composition of considerable tenacity, known among calico-printers by the name of "swimming." By the resistance of the swimming against the oil cloth the latter is pressed against the sieve bottom which rests upon it, so that the latter forms an elastic table or bed over which the fluid coloring matter or mordant employed is spread and diffused, by means of a brush applied by the teer boy, whose duty it is, from time to time, to supply the sieve with the coloring matter or mordant, and to brush over and diffuse the same so that a renewed and uniform surface of such coloring matter or mordant may be presented to the face of the block when applied to the sieve, so as to insure perfect impressions of the fabric in process of printing. The object of this invention is to effect the pur-

* Patented in December, 1834.

pose, before mentioned, of presenting a renewed and uniform surface of coloring material or mordant to which the block may be from time to time applied, without the intervention of the teer boy or assistant, and in a more certain and uniform manner than is effected by the method commonly practised. The manner in which the said machinery and apparatus are to be constructed and used are set forth and ascertained in the description following, illustrated by, and having reference to, the figures or drawings contained in the Plate.

Fig. 1, Plate VI., represents a side elevation of the machinery and apparatus.

Fig. 2, represents a plan or bird's eye view.

Fig. 3, represents a front elevation.

Fig. 4, represents a longitudinal section.

Figs. 5 and 6, represent the separate parts constituting the two ends of the color box hereinafter described.

Fig. 7, represents a plan of the doctor or straight edge, hereinafter described.*

A, is a cast-iron box or cistern open at the top, and, when in use, is covered with an oil-cloth or varnished cloth of the kind used by calico printers in the cases now commonly employed for teering or diffusing the coloring material or mordant. The upper edges of this box, on each side, have a projecting flanch, *a*, over which the edges of the oil-cloth covering are lapped and nailed down tight to a narrow wooden moulding, *t*, screwed under the flanches by screws passed from the inside of the box through the small holes at *b*, in the sides of the box as seen at figs. 1 and 4. The upper surface of the oil-cloth covering is represented at W, in fig. 2; and the situation of the wooden moulding under the returned edge or flange of the cistern is seen in figs. 1, 3, and 4. In the side of the box, as seen in fig. 1, is an opening designated by the dotted lines, C, communicating with an upright iron

* Dr. Ure, at page 249 of his "Dictionary of Arts, Manufactures, and Mines," gives a defective description of this beautiful machine. Those of our friends who have copies of the "Dictionary," will please refer.

pipe, *d*, open at the top and attached to, and proceeding from, the outer side of the box in an upward curve, and then assuming a perpendicular direction. This upright pipe is cast distinct from the box, A, and is fastened thereto with screws and nuts, for which purpose the end of the chimney adjoining the box is cast with a flanch to admit of being tapped to receive the screws. This flanch and the screw heads are seen in figs. 1 and 2; between the flanch and the sides of the box is introduced a piece of mill-board or other packing to pack the whole tight and close. *e*, are two arms or stays, which are called the back pulley stays, proceeding from the lower part of the box, A, at one end of it; each of which arms has an upright projection, *f*, at the end farthest from the box, in which is a hole to admit a long screw, *g*, each end of which is turned plain and smooth for about one-third of an inch, and the intermediate length is cut in a screw or spiral. The plain end of each of the screw pieces, *g*, nearest the box, works in a socket sunk in the back of the box which is there thickened to admit of such socket. Each of the back pulley stays, *e*, carries a loose brass nut, *h*, tapped to receive and fit on the screws, *g*, each nut having on its upper side a small hole or gland to admit oil for lubricating. The nuts, *h*, serve as steps or bearings to receive the ends of the axle of a roller, hereinafter more particularly mentioned. The near end of the cast-iron box has two descending arms, i^1, and i^2, see figs. 3 and 4, which support the color or mordant box, B, hereinafter described, and has also two small projections, *x*, one of which has a centre and the other a step or slot to receive the ends of the axle of the roller, 2. *k*, is a bracket projecting from the near end of the side of the box, A. Two arms, b^1, b^2, are screwed to, and descend obliquely from, the bracket, *k*, to carry at their lowest extremities the two bearings for the axle, *m*, of the grooved pulley, m^2. The axle, *m*, projects beyond the arm, b^2, towards the color box, B, hereinafter described; and on this projecting pad is a longitudinal rib or key fitting into a key bed, in the central hole of the sliding cross or clutch, o^1, the arms of which, when it is pushed home towards the color box, catch the projecting legs of the clutch,

o^2, which is fixed on the adjoining end of the axle of the roller, 1. In figs. 2 and 3, B, is a color box, the front, bottom and back of which is usually made of an entire piece of sheet copper or other suitable metal, or of wood, bent in the form of a trough having a vent pipe or plug hole, y, at the bottom to allow the drawing off of the coloring fluid when necessary.

The material of which the color or mordant box must be composed, will vary with the coloring matter or mordant to be used, but as the action of acids is familiar to calico-printers, every competent workman will be quite aware of the effects which the use of different metals in the structure of the color box will produce on the colors he employs. The ends of the color box may be most conveniently made in the forms represented in figs. 5 and 6; fig. 5, representing the parts of the end nearest the driving pulley m^2; and fig. 6, the parts of the other end; each end is made in two pieces, an upper and a lower, q^1 and q^2; figs. 5 and 6, are the lower pieces, and r^1 and r^2, the upper pieces of the respective ends; a portion of the lower piece, q^1, is recessed inwardly, and a portion of q^2, is recessed outwardly to receive the ends of the descending arms, i^1 and i^2, from the near end of the box or cistern, A. The lower piece of each end is made with an outward flanch all round, and to these flanches the corresponding arms of the trough are rivetted. The piece, q^1, has a hole, 5, by which it is suspended on a pin projecting from the inner side of the descending arm, i^1, nearest the driving pulley, m^2, and the lower piece, q^2, is attached to the other descending arm, i^2, by a screw, n, which passes through the hole, 6, and screws into the adjoining end of the descending arm, i^2, which is tapped to receive it in order to attach together the upper and lower pieces of the ends of the color box. The flanch at the upper edge of each of the lower end pieces, q^1 and q^2, is spread out into a semicircular projection at the nearer end, and the flanch at the lower edge of each of the upper end pieces. r^1 and r^2, are, in like manner, spread out into a corresponding projection, and each corresponding pair of these projections, namely, one upper end and one lower, are united

by means of a screw, m^3, which passing through a hole in the upper projection is screwed into the lower projection which is tapped to receive it. The upper piece, r^1, is made with a notch or fork at its back part which clasps the descending arm, i^1; this fork is seen in the elevation at r^2, fig. 5, and serves to keep in its place the color box, and its adjuncts on the superior margin of each of the upper pieces. r^1, r^2, are two bosses or projecting pieces, 9 and 10, which carry the extremities of a screw, 11, having a pivot and nick turned plain to turn in holes in the bosses as bearings; on each screw, 11, is a nut or moveable piece, 12, tapped to receive the screw, and which, by turning the screw, 11, by its fly or thumb-plate, may be made to travel forward or backward to the extent of the distance between the bosses, 9, 10. The upper end of each nut or shifting piece, 12, terminates in a fork bended horizontally inwards towards each other so as to form bearers for the end of the doctor or straight edge, *s*, best seen in figs. 3 and 7. The back of the doctor is flanged or turned up for the purpose of strengthening it, except at the two ends, which are cut down to admit of their being received into the forks, in which they are kept firm by pins passed through eyes in the upper and lower prong of each fork, and through corresponding holes drilled in the ends of the doctor. 1, 2, 3, best seen in fig. 4, are a series of wooden rollers, of which, 1, is called the lower front roller; 2, the upper front roller; and, 3, the back roller: 4, is also a wooden roller, which may be covered with flannel or similar material, or not covered, according to the degree of tenacity of the coloring matter or mordant employed to take up the coloring material or mordant in the box, and which is, therefore, called the furnishing-roller; each of the four rollers runs on axles supported by the bearings about to be described. The axles of the furnishing-roller, 4, rest in steps which move freely in perpendicular grooves or guides formed in the inside of the ends of the color box, as seen by dotted lines in q^1, and q^2, figs. 5 and 6. These steps are adjusted or moved in a perpendicular direction by means of the screws, *z*, which pass through the under side of the color box for that purpose, so that the amount of

pressure between the rollers, 1 and 4, can be regulated with the greatest exactness. The axles of the lower front roller, 1, rest on the upper edges of the lower pieces, q^1, and q^2, of the ends of the color box, and are retained in their places by caps or openings cast in the corresponding upper pieces, r^1 and r^2. The axles of the upper front roller, 2, run in the centre of the slot or step formed in the projections, x, of the box, A, as before described, and the axles of the back roller, 3, rest in the steps, h, also before described.

On the end of the roller, 1, farthest from the driving-pulley, m^2, is fixed the small spur-wheel, 13, which gears with another spur-wheel fixed immediately beneath it, on the corresponding end of the furnishing roller, 4; the spur-wheels being of such relative size that the face of the roller, 4, may work with a slight rubbing action against the endless web, hereinafter described. The rollers, 1, 2, and 3, carry an endless web, Z, made of the cloth or fabric commonly used among block-printers for forming the bottom of the common sieve, hereinbefore mentioned, or of any other fabric for taking up the coloring matter or mordant, and which web, when the roller 1, is made to revolve, is carried over and in contact with the case or covering, W, of the box, A. The web, in its revolution, passes between two small brackets, 14, fitted to and sliding on the doctor, s, and best seen in fig. 7, at a distance from each other equal to the width of the web, and connected by a wire, 15, in the space between which and the doctor the web passes to put the machine in working order. The box, A, is fixed to a wooden frame, as shown in figs. 1, and 3, the legs of which are represented in the figures as broken off, and are of the height most convenient to the workmen. The box being filled with the swimming, before mentioned, the covering is stretched over the top and projecting edges or flanges of the box, A, and nailed down tightly to the wooden moulding so as effectually to prevent the escape of the swimming; a further quantity of swimming is then poured into the pipe, d, so as to raise the level of the swimming in it a little above the edges of the box, and thereby to produce an upward pressure of the liquid in the box,

against the oil-cloth or covering, the pressure being proportionable to the height of the liquor in the upright pipe. By this means the covering forms a firm elastic table; the endless sieve or web, Z, is then extended over the elastic table thus formed over the rollers, 2, and 3, and under the roller, 1, as best shown in fig. 4, the tension of the endless web may be regulated by varying the position of the back roller, 3, which, by means of the adjusting screws, *g*, acting on the moveable steps, *h*, may be made to approach to, or recede from, the back of the box, as occasion may require. In like manner the degree of force with which the doctor or straight edge, *s*, shall bear on the endless web may be regulated by means of the adjusting screws, 11. The machine being thus adjusted, the vent hole, *y*, of the color box is closed up, and the fluid coloring material or mordant intended to be used is poured into the color box, B, to such a height that a sufficient quantity may be taken up by the roller, 4, in its revolutions, the grooved pulley, m^2, being turned by a strap or cord from a revolving shaft worked by steam or other power, or by hand, the clutch sliding coupling, o^1, is pushed to the end of the pulley axle, *m*, so as to gear with the clutch, o^2, as represented in fig. 2; the roller, 1, on the axle of which the clutch is fixed, is thus caused to revolve and by means of the spur wheel, 13, and the one gearing with it, as before described, drives the furnishing roller, which, as it revolves takes up the coloring fluid or mordant from the color box and imparts it to the endless sieve or web, Z, in its passage under the roller, 1. As the endless web traverses from the roller, 1, to the roller, 2, it bears against the doctor, *s*, by which the superfluous color is scraped off and falls into the color box, to facilitate which the axes of the rollers, 1, 2, are not placed in the same perpendicular, but in an oblique line, the roller, 2, being a little more forward than the roller, 1; the small brackets, 14, on the doctor further scrape off the superfluous color from the edges of the endless web. As the endless web progresses over the elastic table formed by the extended covering, the printer applies his block to it as to the common sieve, the raised pattern on the face of the block

thereby receiving the color or mordant which is to be transferred to the fabric in the process of being printed.

IV. The *fourth series* of improvements* in block-printing, are of the invention of Mr. Robert Hampson, of Manchester. In Plate VII., fig. 1, is a side elevation of a machine for block-printing. A, is a roller or wooden cylinder, on which the fabric to be printed, is wound; and S, a similar roller, provided with a length of calico or other cloth, to pass under the fabric, and protect the blanket during the printing process. *a*, *a*, represent carrier rollers, under the one and over the other of which the fabric and under-cloth are carried in their passage towards the printing table B, over which they pass.

The rollers, A, and S, are both prevented from revolving freely, by means of a break or check line, and the counter-weights, *b*, *b*, so that the fabric and under-cloth are held in a state of moderate tension as they are drawn forward over the printing table, B. The position at which the impression is given to the fabric, is immediately over the letter, B; whence the fabric passes forward over the roller, C, and there separates from the calico or under-cloth, which passes between the roller, C, and the pressing roller, *c*, which is held in close contact with the under surface of the roller, C, by means of the small levers and counter-weights, D, D.

On the axis of the roller, C, is placed the spur-wheel, E, which receives motion from the pinion, *e*, when made to revolve, by means of the handle or winch, F. This handle or winch is arranged to make one revolution for every intended progressive movement of the fabric, having reference to the depth of the pattern or portion of the pattern intended to be impressed thereon, and is held stationary, during the printing operation, by a small spring catch, *f*.

The amount of revolution imparted to the wheel, E, necessarily depends on the relative size of the pinion, *e*, which can be changed when required, so that as soon as one impression has been received on the fabric, at the point, B, a

* Patented in June, 1840.

uniform amount, in length, of the fabric, corresponding with the amount printed, is drawn forward by the revolution of the cylinder, C, and a fresh portion of the fabric presented to the printing operation.

After the fabric has received the impression from the block, and passed forward over the roller, C, it is carried over a heated plate, *d*, *d*, for the purpose of drying it, and thence forward under the carrier rollers, g^1, g^1, then over the pressing roller, *c*, and under or over such carrier rollers as may be convenient, until it is deposited, printed, and in a dry state, on the roller, R.

The heated surface, *d*, *d*, for the purpose of drying the printed fabric, is produced by a constant flow of hot water or steam within a chamber, of which *d*, *d*, forms one side; but the mode of heating may be varied, according to the nature of the fabric to be printed.

The block, G, from which the impression is received on the fabric, is suspended immediately over and parallel to the table, B, where it is attached to the cross-frame, *g*, *g*. This frame is guided and kept horizontal in its ascent and descent within the strong upright frame of the machine, X, X, by means of the centre rod, H, and is suspended in its present position by means of the band, *i*, *i*, and counter-weight, I; so that, by raising the counter-weight, I, the cross-frame and block descend by their own gravity, and the block imparts the pattern to the fabric on the table below, returning to the position represented, as soon as the weight, I, is drawn down by the operator.

The apparatus for distributing the color to the block, G, is represented at K, and moves on the railway, L, L. In the drawing it is shown immediately under the block, G, preparatory to the block being depressed to receive the color, and in dotted lines, in the position to which it would be removed before the block again descended to impart the pattern to the fabric below.

The construction of this part of the invention will be seen in the detached figures, where figs. 2 and 3, represent plans, and figs. 4 and 5, transverse sections of a coloring apparatus,

for distributing six colors to the block at one operation. In these figures, *m*, *m*, *m*, represent eight compartments or small cisterns, in which the liquid colors are contained, ready for distribution on the surface of their respective sieves or elastic surfaces, M, M, M.

The six parallel boxes or cisterns, under the sieves, M, M, M, are supplied, at their respective openings, *n*, *n*, *n*, with the requisite amount of liquid to keep them elastic, and are supported on two straight edges, O, O. The first sieve-box is stationary, but the other five can be separated by means of the bent irons, Q, Q, which are attached to the last sieve, and the amount of separation or distance from each other, at which they are held, is determined by means of a strap of leather, *p*, *p*, (see figs. 4 and 5,) attached to the under side of all the sieve boxes or cisterns.

Fig. 6, is a plan, and fig. 7, an elevation of a feeder or implement for distributing the color from the color cisterns, *m*, *m*, *m*, into the sieves, M, M, M. This feeder consists of a series of wooden pegs, fixed in and proceeding from the under surface of a slab of wood, and so placed as to correspond with the respective color cisterns, so that, by lifting the feeder out of the color cisterns, and placing it on the sieves, when in the position represented at fig. 2, a regular amount of color is carried to each, and the dipper, being returned to the color vessels, remains ready for the next operation.

Fig. 8, represents a teering brush or rubber, *y*, with two handles, which is to be placed in a trough, made for its reception, as seen at fig. 3, when not in use; and is shown in elevation, as when in use at fig. 4. This brush or rubber is for teering or spreading the color uniformly on the surface of the respective sieves, and is divided into spaces to correspond with the sieves when separated, as in fig. 2. The colors having been distributed, by means of the dipper, fig. 7, and spread or teered by the brush, the coloring apparatus is passed along the railway, L, L, under the block, G, where the projections, Q, Q, coming in contact with the upright framing of the machine, the several sieves, M, M, M, are pushed together or closed, as seen at fig. 3, and are then in a position to correspond with

the several portions of the pattern on the block, G, which are to receive the several colors. In this apparatus, the color being distributed in straight lines, the pattern on the block, G, must necessarily partake of the same character; but by variations in the form of sieves, patterns of a different character may be produced.

Fig. 10, is a modification of the coloring apparatus, in which, by the sieves being made with projections or indentations, *x*, filling into each other, alternate colors would be imparted to the block when the sieves were closed, and the block brought into contact therewith; whereas, in the former construction, it would be the same color throughout. But this and other modifications of the coloring apparatus, according to the nature of the pattern to be produced, will be obvious to any party conversant with printing operations,—a principal advantage in the method described, of distributing and teering the color, depending on the moveable arrangement of the sieves, which allow of the near approximation of different colors in the pattern, without endangering their admixture during the process of distribution and teering.

Fig. 9, is an elevation of a brush for cleaning the block, G, when required, which, by moving accurately on the edge of the coloring apparatus, comes in contact with every part of the block on which any part of the pattern is raised, the block being sufficiently lowered for this purpose when required.

The following figures represent a modification of the color-box, adapted to the employment of a printing block, of the ordinary size, to be used by hand, either before or after dyeing, or other process, by which the texture of the fabric to be printed has been stretched, contracted, or otherwise varied, in the same manner as block printing is ordinarily performed, and when the object could not be properly or conveniently effected by a block, covering the whole width of the fabric, as already described.

Fig. 11, is a plan of the color box; fig. 12, is a transverse section of the same, taken at the line, T, T, of fig. 11; and fig. 13, a transverse section, taken at the line, *w*, *w*, of the same fig.

The position of the sieves, when closed and ready to receive the block, is shown at fig. 11; but when not in use, they are placed as shown, in section, at fig. 12.

It will be observed, that in the coloring apparatus, before explained, the teering or spreading of the color was described as performed lengthwise, from end to end of the sieves. In the present modification it is performed across or at a right angle to the longest side of the sieves, which are divided into compartments by small bands or raised divisions, placed across the sieves, to prevent the intermixture of different colors placed on the same sieves.

The various colors are placed in compartments, marked *m*, *m*, *m*, and each is subdivided into a variety of small cells, to contain colors and shades of colors. Thus, at one impression of the block, six or more separate colors are placed on the fabric, and the rainbowed effect produced and intermixed to a greater extent than has heretofore been effected.*

V. The *fifth series* of improvements† in block-printing, are of the invention of Mr. James Capple Miller, of Manchester, and consist in a novel arrangement and construction of mechanism, whereby the pattern or design may be printed upon the goods or fabrics, by the agency of machinery, worked by steam or other adequate power.

The peculiar department of printing calicos, muslins, &c., to which these improvements are more particularly applicable, is that process usually denominated block-printing, which is ordinarily performed by manual labor; the design or pattern to be printed, being first traced on the surface of the blocks, and small portions of a single color impressed upon the cloth, by the hands of the workman, the intervening and finishing colors being separately printed at successive intervals.

The advantages attainable by this invention are, firstly,

* Mr. Parnell, at page 137 (American edition) of his "Applied Chemistry," represents this valuable machine by a portion of the framing only; and which he calls "a sketch of the *principal parts* of this very ingenious press-printing machine." It is, we believe, quite common for writers of Mr. Parnell's practical experience in mechanics, to consider the *framing* the principal part of the machine.

† Patented in August, 1839.

the capability of printing two, three, four, or more colors, at one operation; and secondly, completing the printed pattern upon the whole width of the piece of goods, or upon two or more pieces, side by side, in the same machine; and by having another table, and set of impression boxes and color boxes, the same movements may be applied, so that the carriage, in retiring, may print two or more pieces, and in advancing, print also two more.

In Plate VIII., are several views of the improved machine, calculated to print two pieces, or two different patterns, on the same block, of calico, muslin, or other fabric, side by side, (or four pieces, the carriage printing both ways,) the intended pattern, or device, to be printed, consisting of four colors, to be printed from blocks.

Fig. 1, represents a side elevation, fig. 2, a front view, and fig. 3, a transverse section, taken through about the middle of the machine.

The side or main framing of the printing machine, is shown at *a*, *a*, supporting the color boxes, *b*, *b*, *b*, with their respective "doctors;" the furnishing tables or beds, *c*, *c*, *c*, (which are a substitute for the sieve in ordinary block-printing;) the printing table, *d*, *d*; and the feeding, drying, and delivering rollers, *f*, *f*, *g*, *g*, *h*, *h*.

The machine is also provided with a carriage, *i*, *i*, for the printing blocks, *j*, *j*, *j*, *j*. This carriage, *i*, *i*, travels in and out, at suitable intervals, upon rails, *k*, *k*, attached to the main framing,

The operation of the machine is effected, by passing a driving-strap, *l*, connected, by shafting, to the steam-engine, or any other adequate power, round the driving-pulley, *m*; fixed at the extremity of the main driving-shaft, *n*, *n*. At the other end of the shaft, *n*, is keyed the bevil-pinion, *o*, gearing, at suitable intervals, (hereafter explained,) with the bevil-wheel, *p*, which is mounted upon one end of the cross-shaft, *q*; at about the middle of which, the mitre-wheels, *r*, *r*, driving the upright shaft, *s*, *s*, and mitre-wheels, *t*, *t*, above, actuate, by means of the spur-pinions, *u*, *u*, the feeding-rollers, *f*, *f*, and thus draw the pieces of goods into the machine.

Simultaneously with the progress of the cloth, the mitre-wheels, *v*, *v*, at the other end of the cross-shaft, *q*, drive the furnishing-rollers, *w*, *w*, *w*, by means of the spur-gearing, *x*, *x*, *x*. The furnishing-rollers, revolving in their respective color-boxes, spread or supply the colors upon the travelling endless blankets, *y*, *y*, *y*, which pass around the top roller, and the furnishing-tables or beds, *c*, *c*, *c*, in order to supply the colors to the surfaces of the printing blocks, *j*, *j*, *j*.

It may be here remarked, that either the beds, *c*, or the backs of the printing blocks, may be made slightly elastic, to insure the perfect taking-up of the color by the blocks.

Supposing now the carriage, *i*, *i*, to be run out upon its railways, at the farthest point from the beds, *c*, *c*, it is drawn inwards towards the furnishing-beds, *c*, *c*, by means of the spur-wheel, *z*, upon the driving-shaft, *n*, taking into a small pinion, 1, (shewn by dots in fig. 1,) upon the shaft, 2. On the end of this shaft is also keyed the mangle-pinion, 3, gearing in the mangle-wheel, 4, which is keyed upon the end of the shaft, 5. This shaft drives the spur-wheel, 6, in gear with the pinion, 7, fast upon the shaft, 8,—see fig. 3.

Upon either end of the shaft, 5, is a rack-pinion, 9, taking into the horizontal rack, 10, fast on the carriage-frame, *i*, *i*, and thus the blocks, *j*, *j*, *j*, are presented to the furnishing-blankets, *y*, *y*, *y*, and take a supply of color ready for printing. The travelling carriage and blocks now retire, by the agency of the mangle-wheel and pinion, 3, and 4, the pinion being fast upon the end of the shaft, 2, and the wheel being fast upon the other shaft, 5, in a line with the shaft, 2. At this time, another operation of the machine takes place:—

Upon the reverse end of the shaft, 5, is a pinion, 11, gearing with the spur-wheel, 12; and by means of the spur-gearing, 6, and 13, and counter-shaft, 14, the pinion, 15, drives the spur-wheel, 16, which corresponds to the wheel, 12, on the other side of the machine. To one of the arms of these spur-wheels are attached, by bolts, two quadrant levers, 17, 17; and as these wheels revolve, by means of the gearing just described, the levers, 17, 17, draw down the chains, 18, 18, and ac-

tuate the levers, 19, and 20, and thus elevate the whole series of printing blocks in the parallel grooves, 21, 21, at the same time pressing or closing them into one mass or block, by expanding the springs, 22, 22, and at the next advance of the carriage caused, at the proper interval, by the agency of the mangle-wheel, the blocks are made to impress the pattern upon the surface of the goods, at once, in four or more different colors, and in one, two, or more widths of cloth, at one operation.

The cloth is now drawn forward, for the space of the exact width of one of the blocks or sketch of the design, by means of the spur-wheels and pinions, 23, 23, and passed around heated cylinders, *g*, *g*, if necessary, and between the delivering-rollers, out of the machine. These operations are to be repeated, by the continuous rotation of the main driving-shaft, until the printing is completed, the colors making a single advance upon the pattern at every presentation of the blocks, until the whole number of blocks have been presented to the same space or portion of the goods successively.

It will be observed, that steam-pipes, 24, are to be in connection with the printing table and drying cylinders, in order to supply a degree of steam-heat during the operation, which may be regulated at pleasure.

To give suitable intervals of rest and motion to the various parts of the driving gear, an ordinary clutch-box, 25, shewn in the drawing, fig. 1, and regulated by suitable stops, fixed to the travelling carriage, is used for throwing the wheel, *p*, in and out of gear with the pinion, *o*;—this is to prevent cloth or colors from being dragged upon the blocks.

VI. The *sixth series* of improvements* in block-printing, are of the invention of Mr. William Wood, of High Holborn, London, and apply principally to printing or staining fabrics of the *carpet* kind, whether manufactured by the known processes of weaving, or felting; the object being to communicate to, or deposit upon, these and the like fabrics such copi-

* Patented in December, 1844.

ous supplies or quantities of dyeing material as will be sufficient to penetrate deeply into the fabric, in order to dye or stain it through or down to the ground-work, or nearly so: *the ordinary modes of printing being, in general, only capable of coloring the surface*, or a very little way below the surface. By this improved means Mr. Wood states, that he is enabled to print or stain fabrics which have a raised terry, pile, or nap, such as the fabrics commonly called or known by the denominations, *Brussels carpeting*, or *Wilton carpeting* and the like; or thick fabrics without pile, such as *Kidderminster carpeting*, and *druggets*.

In carrying out this object, a series of cells or compartments are provided, capable of holding a considerable quantity of the dyeing or staining matter. These cells or compartments may be arranged, either upon a level or a curved surface, in any figures or devices capable of producing patterns. The cells are divided by partitions, in order to limit and define, laterally, the flow of the dyeing or staining materials; the several colors employed being placed in separate cells, according to the desired colors of the pattern to be produced. These arrangements being made, the face of the fabric is brought into contact with the open parts of the cells, and caused to dip or penetrate into the cells, for the purpose of taking up such quantities of the coloring matter as will suffice to dye or stain those parts of the fabric operated upon to the depth required. In the first place a flat plate or surface (to be made of metal) is provided; upon this plate narrow strips or ribs of metal are set upright and arranged into figures or forms, agreeable to any required pattern. These are soldered or otherwise attached to the plate, so as to constitute separate cells or receptacles for the coloring matter, the upper edges of the strips being all level or coincident, so as to produce an even surface.

In Plate IX., fig. 1, represents a portion of a flat plate, A, A, A, having the elevated ribs, strips, or partitions, *a*, *a*, *a*, of thin metal set up on its surface, by which the cells, to hold the coloring matter to produce the pattern, are formed. B, B, B, is a continuous cell, formed to the desired figure, containing,

say a pale green color, which is supplied through a flat pipe, *b*, from a pan or reservoir (at the side of the table, but not shown in the drawing); and when the first cell, B, B, B, has become filled, the color flows from thence by other communicating pipes, *b**, *b**, to corresponding cells, B*, intended to form similar parts of the pattern at other parts of the plate. The cell, C, C, C, is for producing another shade and portion of the figure; it contains, say a dark green color, which is conducted into it, in the way before explained, by the pipe, *c*, and passed thence by the pipes, *c**, *c**, to other parts of the pattern, C*. The cell, D, containing, say a brown color, is supplied, by the like means, through the pipe *d*, and that color is conducted forward by the pipe, *d**, to the cell, D*. The ground color, say ruby, intended to cover the main part of the fabric, is made to flow over the surface of the plate, A, A, A, and over the before-mentioned feeding-pipes, as shewn in the drawing, and is confined within the marginal ribs, E, E, E, on the outside. This apparatus being so prepared, the face of the fabric to be printed or stained is brought over and pressed upon the upper surface of the partitions, *a*, *a*, *a*, on the plate, A, A, A, by a flat platten, as in the ordinary way of type-printing; by which means certain parts of the surface of the fabric are forced into the cells or recesses containing the coloring matter, and it thereby becomes stained or dyed with the several colors in those parts where the pattern is intended to be produced.

Fig. 2, represents an elevation, partly in section, of a press, well calculated for the purpose of printing or staining fabrics of the kind described, by means of the improved apparatus, viz., a plate with cells, as shewn at fig. 1. This press the patentee does not intend to claim as new, but shows it merely for the purpose of explaining his mode of printing or staining more perfectly. The cloth or fabric, *a*, *a*, *a*, to be printed, is wound upon the roller, *b*, and thence conducted under the roller, *c*, in a horizontal direction, to the rollers, *d*, passing, face downwards, over the dyeing-plate, A, A, before described, which plate is laid upon the table of the press. The table, whereon the plate, A, rests, is heated by a steam chest, B,

below, of which indeed the table may be said to form the upper part. The cells of the plate, A, A, being filled with colors, by the means described, or by any other means that may be found eligible, that portion of the distended fabric, *a*, *a*, which is stretched over the face of the plate, A, A, is pressed upon the upper surfaces of the partitions, and the parts intended to be printed are made to dip into the cells of the plate by the descent of the platten, C, and having remained there a sufficient time to take up the necessary quantity of color or dyeing material, the platten is raised and the cloth drawn onward. In the progress of the cloth toward the taking-up roller, *e*, it passes over a hot plate, D, for the purpose of drying the color. This plate may be conveniently heated by the flame of jets issuing from a gas-pipe E, (see detached portion of fig. 2,) though it may be done by other means; and, indeed, it may not always be necessary to dry the coloring matter upon the fabric in this part of the operation.

Having explained the construction of the improved plate, with cells capable of printing four colors at one operation, and the manner of applying it in a press to the purpose of printing or staining fabrics, the patentee proceeds to show a modification of the apparatus, by which a great variety of colors may be printed upon the fabric at one time.

Fig. 3, represents a series of angular tubes, *a*, *b*, &c., connected together, side by side, in close contact, by solder or other convenient means; and fig. 4, is a vertical section of the same; the top surfaces of these conjoined tubes form together a flat surface, equivalent to the plate first described. Upon this flat surface, strips or ribs of metal are arranged, as before, in such curved or other shapes as will correspond with the outlines of the pattern intended to be printed, in order to produce distinct cells or receptacles for the coloring matter, the strips or ribs forming the partitions between the cells. The colors, or coloring matters, in a fluid state, are supplied to this apparatus from pans or reservoirs in the sides, from whence the several coloring fluids will pass into the pipes, *a*, *b*, &c., and rise through small openings from the several hori-

zontal pipes into the several recesses or compartments. Care must, however, be taken that the coloring matters do not overflow from one compartment into an adjoining compartment, for, if that occurred, the patterns would become ill-defined and confused; but this defect is prevented by keeping the surface of the coloring material in the pan at the same level as in the recesses.

The surface of fig. 3, it will be seen, is divided into cells, A, A, B, B, &c., by the ribs or strips of metal; it will, therefore, merely be necessary to say, that the lateral trough, A*, being supplied with a red coloring matter or dye, that color will flow through the communicating pipes, *a*, *a*, *a*, to the several cells or compartments, A, intended to contain the red liquor; and the cells B, B, will, in the same manner, be supplied with a slate color from the lateral trough, B*, through the pipes, *b*, *b*, *b*. All the other compartments will be supplied by similar means with their respective colors, from lateral troughs through pipes; each of which pipes has a small aperture, or apertures, through which the liquor flows upwards to the several compartments.

Another mode of constructing cells to contain the coloring liquor is, by forming pipes or hollow tubes in small pieces, about the size and shape of printing types, which may be combined into figures by the ordinary means of composition: hollow types being employed for forming the cells, and solid types for the blank parts of the pattern. These types having been composed into the desired figure, may be placed over a trough containing the coloring liquor, and the cloth being laid thereon, the liquor may be forced up through the hollow types into the fabric by any convenient means. A convenient mode of applying these hollow types is shown at figs. 5, and 6. Fig. 5, is a horizontal view of a form of these types set up to represent a diamond pattern, the types being circumscribed, and held fast by a frame or chase, A, A, A. The tinted squares represent the hollow types, through which the coloring matter is forced on to the fabric, and the other parts are solids or blanks. Fig. 6, is a vertical section of the same. The frame, A, A, A, is a box, in the mouth of which the

types are inserted and made fast. Within this box a vessel, B, is attached, intended to contain the dyeing or staining material in a semi-fluid state; the sides of the vessel being formed of a flexible material. When the form of type has been placed upon the fabric to be printed in the usual way of applying blocks for printing, the moveable top of the vessel B, is to be slightly depressed, for the purpose of forcing a quantity of the dyeing or coloring matter through the hollow types on to the fabric. Another mode of adapting these hollow types to the purpose of dyeing or staining fabrics is shewn at fig. 7. This consists of a hollow cylinder, A, perforated with small holes, into which the smaller ends of types are to be inserted; the whole periphery of the cylinder being covered with types set radially. Agreeable to the pattern or device to be printed, the hollow types are inserted at certain parts of the cylinder, and when the interior of the cylinder is charged with the coloring material, the cloth or fabric passing under the hollow types will be printed. The coloring matter being of such a consistency as will only fill the hollow types, but not flow freely through them, a volume of steam, at a slight degree of pressure, is conducted through the central axle, in order that it may fill the chamber or passage, B, which extends the whole length of the cylinder; by which pressure of the steam the coloring matter will be forced through those hollow types which are in contact with the cloth below, and dye or stain it accordingly.

Fig. 8, represents in sectional elevation, an improved apparatus, whereby a rotary surface-printing cylinder is applied to the printing of woven and other fabrics; *a*, *a*, is the printing cylinder; and *b*, a roller, mounted and revolving in the color trough, *c*, for taking up and depositing color upon the surface of the cylinder. The raised parts or surfaces of the patterns on this cylinder are perforated, as shewn at *d*, *d*, *d*, and when the pattern has been supplied with color from the roller, *b*, and by the revolution of the cylinder, *a*, is brought under the steam passage or chamber, *e*, similar to that above described in fig. 7, the steam will enter the perforations, and force out the color on to the fabric, while, at the same time,

the pressure of the cylinder on the fabric will cause the color on the solid parts of the pattern to be taken off. The perforations may, if thought desirable, be covered with woolen cloth, or other porous material.

VII. We shall close this chapter with a description of an invention* of Mr. John M'Intosh, of Glasgow, having for its object, first, the combining of the flock, of any required color, with a clear solution of India-rubber or of gutta-percha, and employing the mixture for printing on calico, paper, or other fabrics, in place of the usual coloring materials. This mixture is printed on the fabrics in the same manner as when the ordinary colors are used; and the flock is caused to adhere firmly thereto by the India-rubber or gutta-percha. The solution of India-rubber or gutta-percha is preferred to be made with naphtha.

The second part of this invention consists in applying a roller, coated with India-rubber, to engraved rollers or plates, for the purpose of keeping the engraving clean. In printing from engravings on rollers or plates, it has hitherto been the practice to wash out the engraving frequently, in order to remove the color that has dried thereon; instead of which, the patentee causes a roller, coated with India-rubber, to press against the engraved roller, as it revolves, and thereby remove the coloring matter that would otherwise adhere thereto: when applied to an engraved plate, the roller is caused to pass to and fro over the plate.

The last part of this invention consists in a contrivance for spreading the color on a suitable sieve-cloth or felt, from which it is to be taken up by the blocks used in block-printing. In Plate VII., fig. 1, is a longitudinal section, and fig. 2, a transverse section of the apparatus. *a*, is a bag containing water suitably thickened, as usual in making sieves for block-printing; *b*, the framing that supports the sieve; and, *c*, a felt, spread evenly over the sieve, and fastened at its edges to the frame. *d*, is a trough, containing the color, and *e*, *e*, are brushes; and it is the use of a trough to contain the

* Patented in May, 1845.

color, moving over the surface of the felt or sieve-cloth with the brushes (instead of simply using a brush to spread the color), which constitutes the novelty of this part of the invention. The lower part of the trough is open, and presses upon the sieve-cloth; hence, as the trough is moved, a quantity of color is deposited upon the sieve-cloth, and spread evenly by the brushes.

CHAPTER IV.

RECENT INVENTIONS AND IMPROVEMENTS IN DYEING AND CALICO-PRINTING PROCESSES.

CYLINDER-PRINTING, ETC.

I. THE *first series* of improvements in cylinder-printing which we shall introduce in this chapter to the notice of the reader, are of the invention of Mr. Richard Beard, of Egremont Place, New Road, London, and for which he obtained patents in June, 1839, and October, 1843. The first part of these improvements consists in printing two or more colors from the same cylinder; this is effected by arranging the pattern thereon in such a manner that all those parts which are required to be of the same color shall follow one another around the cylinder in a direct line, so that no crossing or mixture of the colors may take place. When engraved cylinders are used for printing, according to this improvement, the color trough is divided, by transverse partitions, into as many compartments as there are rows of color required to form the pattern, and in each compartment is a small color-roller, mounted upon an axis, which extends the whole length of the trough.

In Plate X., fig. 1, is an end view of the color trough and its appurtenances; and fig. 2, is a longitudinal section of part of the same. *a*, is the color trough; and *b*, the printing cylinder, which is supplied with different colors by the rollers, *c*, fixed on the shaft, *d*. Any superfluous color is removed from the cylinder by the "doctor" or scraper, *e*, and is conducted into its proper division of the trough by the partitions, *f*, (one of which is shown separately at fig. 3,) inserted between the various compartments, and kept in contact with the cylinder by means of springs, *g*. If cylinders with raised

printing surfaces are used, a "furnishing-roller" is interposed between each color-roller and the cylinder.

The second part of this invention consists in a mode of supplying color to cylinders, which have their printing surfaces in relief, by means of a peculiar construction of roller, termed a "transmitting-roller." Around the surface of this roller, and extending the whole length thereof, are twelve slides, having a number of raised color surfaces, covered with cloth; on the under-side of each slide a pair of rollers are mounted, which work against eccentric guides in the interior of the transmitting roller; so that, as the transmitting-roller revolves, the slides will be moved a greater or less distance endwise, according to the degree of curve given to the guides. The color surfaces are supplied with color by a row of carrying or furnishing-rollers, which work in contact with the color-rollers; and any excess of color is removed from the carrying-rollers and color surfaces by the doctors. The reason for moving the slides endwise is, to cause those surfaces which are to receive the same description of color to follow one another in a direct line, as they approach the carrying rollers; and, after receiving the color, to be arranged in suitable positions for transmitting it to the required parts of the pattern.

This will be more clearly understood by reference to the diagrams, figs. 4, and 5; fig. 4, representing part of some of the slides in suitable positions for transferring the color to the printing cylinder; and fig. 5, shewing their relative positions when in readiness for having the color applied to them by the carrying-rollers. The colors to be printed are supposed to be brown, green, pink, and violet, represented by the letters, *b*, *g*, *p*, and *v*, which are also marked upon the corresponding carrying-rollers, seen at fig. 6; and it will be perceived that the ends, *, of the slides range evenly together, when transferring the color to the printing cylinder; but that, when receiving the color, some of the ends project beyond the rest, in order that the corresponding color surfaces may range in suitable lines, as above mentioned.

The third improvement consists in producing cylinders with

printing surfaces in relief, by fixing suitable raised figures or designs upon metal cylinders. A solder, consisting of twenty parts of pewter, eight of lead, four of bismuth, and one of antimony, is preferred to be used for fixing the designs on the cylinder; the surface of which is first prepared by coating it with a mixture of three parts of water, three of muriatic acid, and one of sal-ammoniac. The under surface of the parts forming the design is coated with the solder; they are then placed in their proper positions, and held for a short time, while a hot iron is applied to their upper surface, to make them adhere.

The fourth and last improvement consists in forming cylinders for relief-printing of any suitable cement or composition (which will become sufficiently hard when cold, and will not be liable to injury in the operation of printing), and inserting therein the figures composing the design. The composition, preferred by the patentee, is made by melting one part of asphaltum, with one of hog's lard, and five parts of black pitch, with two of white pitch, and then intimately mixing these ingredients with twenty parts of sand, and five of red ochre. The figures are sunk into the cylinder (which is formed of the above composition) to the depth of about three-eighths of an inch, by means of a hot iron, and pressure; and any irregularity in their surfaces is afterwards reduced by filling.

The invention patented under the patent of October, 1843, above referred to, relates to the "transmitting, or sieve rollers" used for supplying color to cylinders which have their printing surfaces in relief. The improvement consists in giving the requisite elasticity to those rollers by the use of glutinous or gelatinous matter, which will yield to pressure, and return to its original form when the pressure is removed.

The composition preferred by the patentee is made of glue and molasses, in the proportion of from two to three pounds of glue (which has been steeped for about six hours) to four pounds of molasses; this mixture is boiled for four or five hours, and kept constantly stirred. The apparatus used for making this composition into rollers, is represented in Plate

X., fig. 7, being a vertical section, and fig. 8, a plan thereof. *a*, is a cylinder, formed by bending a plate of zinc, or other suitable material, and it is retained in that shape by hoops, *b*, provided with screws and nuts; *c*, is an axis for the roller, with suitably turned necks, at its ends; and *d*, *d*, are circular plates fixed on the axis, *c*, to form the ends of the roller; the upper plate having two holes in it, through one of which the composition is poured (the mould having been previously oiled), and through the other the air escapes. After the composition roller is removed from the mould, it is covered with oil-cloth, and over this is placed elastic cloth or felt, which has been previously coated with India rubber on the side which comes in contact with the oil-cloth; the object being to prevent the liquid color from penetrating to the composition. The roller is now ready for use.

When several colors are to be printed by the same cylinder, as described and illustrated by the figs. 1, 2, 3, 4, 5, and 6, as above stated, the surface of the composition roller is divided into the requisite number of transmitting surfaces by circular plates. Fig. 9, is a transverse section, and fig. 10, a front view, of part of a color trough, with the rollers and cylinders to be used in printing calicos, &c. *e*, is the trough, divided into a number of color spaces by partitions, *f*; in each space a color roller, *g*, is mounted, and by these the colors are supplied to the sieve-roller, *h*, by which they are transmitted to the printing cylinder, *i*; *j*, is the bowl or bed roller, round which the cloth passes to be printed; and *k*, is a common printing cylinder, for printing the ground of the pattern. Each transmitting surface on the roller, *h*, is separated from the rest by its pair of plates, *d*, and the colors are effectually prevented from becoming mixed by the partitions, *f*, entering the spaces between the transmitting surfaces; any superfluous color is removed by the doctor, *l*, part of which is shewn separately at fig. 11.

II. The *second series* of improvements* in cylinder-printing are of the invention of Mr. Joseph Leese, of Manchester

* Patented in June, 1840.

The improvements consist, firstly, in the substitution of a novel description of fabric or material to be employed in printing, instead of the ordinary blanket, felt, or other lappings, now commonly used upon printing machines and tables; and more particularly with reference to printing calicos, muslins, and other similar woven fabrics; secondly, in a novel arrangement of apparatus, for the purpose of printing calicos, &c., with blocks, either in combination with the ordinary cylinder printing machine, or separately; thirdly, in a novel construction of mechanism to be applied to ordinary calico printing machines, for the purpose of (what is technically called) "rainbowing" colors, in the cylinder printing machine, instead of performing such operation, separately, by hand blocks, as heretofore; and lastly, substituting a peculiarly prepared fabric, to be used in cutting and forming printing surfaces, either on blocks or cylinders, instead of employing felt, generally used for such purpose.

The first part and main feature of this invention is as follows:—Instead of using the blanket, felt, or other ordinary bed or lappings, in cylinder or block-printing machines, or on printing tables, a fabric, composed of one, two, or more thicknesses or folds of common calico or other cloth, is used.

Upon and between these folds of cloth, thin layers or coverings of India-rubber solution are spread. The degree of elasticity in thickness, and the strength of the fabric, may be varied to suit the purpose for which it is intended to be used, and will, of course, depend upon the number of layers of cloth and India-rubber, so combined, and also the quality of the fabrics employed; as, for instance,—if great strength and considerable elasticity of surface is desired, a piece of stout unbleached calico is coated with India-rubber, and fold laid upon fold, alternately with the layer of India-rubber solution, until the required substance is attained. Or two or three stout pieces of calico, or woolen cloth, or cotton and woolen combined, may be connected by the solution of India-rubber placed between them, thereby producing an adhesion to each other, as firmly as if the fabric had been woven in one piece. This fabric may also have upon its surface a

thick layer or coating of India-rubber; and, in this case, the whole endless sheet or blanket, when once united, at its ends, in the printing machine, may readily be washed, without the necessity of unstitching and removing it from the machine.

The advantages of the employment of such improved fabric or material, in place of the ordinary blanket and lappings, in printing, will be evident; first, from the great elasticity of the surface to print upon, which will enable the machine to bring out, or produce, a much finer impression than those usually obtained; and also with much less power or pressure than is commonly required; secondly, this fabric has greater strength and durability, as the layers of India-rubber save the wear of the cloth, by preventing the friction resulting from the rubbing of threads, one against another; and lastly, its extreme economy or cheapness, compared with the usual cost of blanketing.

The second and third parts of the improvements will be more readily understood by reference to Plate X. Fig. 1, represents a side elevation of an arrangement of apparatus, constituting a machine for printing calicos, &c., to which the above described material or lapping is particularly applicable, owing to its length never varying, after its utmost tension is obtained, and its elasticity being in its thickness only; whereas an ordinary blanket or lapping, could not be effectively employed in a similar arrangement of mechanism, from its liability to stretch, and thus misplace the print and prevent the possibility of fitting the pattern. It consists of stout side-frames, *a*, *a*, (their distance apart being regulated by the width of the goods to be printed,) supporting two cylinders or bowls, *b*, *b*, one at each end; around which the endless band, *c*, *c*, is passed, and which may then be drawn to its required tension, by means of the screw, *d*; the printing cloth or blanket is now ready to receive the cloth to be printed, which may enter the machine at *e*, extending upwards, as at *f*, *f*; a series of iron arms or frames, *g*, *g*, extend from the main side-frames, and are provided with plain mortices, for the purpose of guiding the printing-blocks, *h*, *h*, which are to be slidden backwards and forwards in them. The frames, *g*, *g*, also support

the color boxes, *i*, *i*, and the rollers, *k*, *k*, around which the endless sieve-cloths, *l*, *l*, are passed.

The ends of the printing-blocks, *h*, *h*, are made fast to the pinions, *m*, *m*, and turn in one end of the slide or working-rods, *n*, *n*; thus it will be seen, that as these rods, *n*, are worked or slidden forward, (either by the hands of the printer, or by any suitable mechanical contrivance,) the pinion, *m*, will, by working in the straight-rack, *o*, *o*, underneath, turn over the printing-block, *h*, and cause it to strike against the sieve-cloth, *l*, and thus be furnished with color; when, by the rod, *n*, being drawn backwards, the printing block will again be turned over, with its printing surface towards the cloth, *f*, *f*, and will print the design or pattern upon it.

It will be seen in the drawing, that a small bed or table, *p*, *p*, is placed under the furnishing and printing cloths, in order to prevent any misprint or sudden concussion of the block. These tables are furnished each with a back or bed-spring, *q*, *q*, and have projecting pieces at their ends, for the purpose of guiding the block square on to its work, and prevent one side or end coming first in contact with the cloth; see detached plan view, fig. 2.

The improvement in "rainbowing colors," by this machine, will be understood by reference to fig. 3, which is a vertical section, taken through the middle of the machine. *a*, *a*, is the frame of a calico cylinder printing machine, supporting the printing-bowl, *b*;—*c*, *c*, is a common surface printing-roller; and, *d*, *d*, is a stand or frame, supporting the various color-boxes, *e*, *e*, *e*, *e*. The endless sieve-cloth, for furnishing the colors, is shewn at *f*, *f*, tightly distended over the rollers, *g*, *g*, *g*, *g*, *g*.

The several axes, *i*, *i*, *i*, *i*, are supported in small adjustable pedestals; upon these axles are mounted discs or rollers, *j*, *j*, *j*, *j*, which, as they revolve, dip into the color-boxes, and being furnished with pins or teeth, they thus take up the colors from the color-boxes, and deposit them upon the sieve-cloth, which furnishes the surface printing-roller. Each of the color-boxes composing one series, contains a different shade of the same color, and the discs or rollers, *j*, are so

placed, that the various shades, when spread on the sieve-cloth, will be abreast of each other; thus "the rainbowing" is produced, and conveyed to the surface-roller. These discs or rollers, *j*, are composed of wood, furnished with copper pins or wires, which are capable of being put up or down, in order to regulate the quantity of color to be transferred from the color-boxes to the sieve-cloth; by the travelling motion of which they are respectively driven, the points or wires being in contact therewith.

Another improvement, more particularly adapted to paper printing, consists in winding the paper or fabric to be printed, upon the bowl of the printing-machine, instead of its being wound on a roll, and then drawing it through the machine from the back. The bowl of the machine may be made to take in and out, so that there may be more than one in use, and thus delay is prevented.

When the machine is to be set to work, the paper or cloth is wound on the bowl, and the rollers are set up to it, as in printing in the ordinary way; the only difference being, that the diameter of the bowl decreasing, as the paper is printed off it, the rollers must be constantly kept up to it.

The last improvement consists in substituting any fabric after it is coated on one side with India-rubber, for the hatting or felt commonly used in coating printing-blocks, surface-rollers, &c. If the block or surface be required to work a very heavy solid pattern, the whole of the block or surface may be covered with the prepared cloth; the parts not intended to print being afterwards cut out, and if necessary the edges may be coppered, where the blocks are required to work finely.

This part of the improvements consists also in placing at the bottom of the engraving of a deeply-engraved copper cylinder or roller, any suitable cloth or fabric, previously prepared with a coating of India-rubber on one side; the object of this is to produce an even solid print, and also to furnish a good supply of color to the piece, the roller being engraved sufficiently deep to allow the doctor to pass over the surface of the roller without touching the surface of the cloth.

III. The *third series* of improvements* in cylinder-printing, are of the invention of Mr. William Shepherd, of Manchester. The improvements apply chiefly to printing piece-goods, and consist, in the first place, in the application to such purposes of a peculiar preparation of caoutchouc or India-rubber, now commonly termed "vulcanized India-rubber," either employed as a covering for rollers or bowls, or used as an endless printing-blanket or web, in lieu of the ordinary woolen or other blanket at present employed.

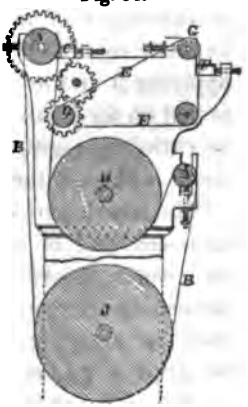
It is stated that the elasticity or compressibility of the vulcanized India-rubber surface or blanket is much more uniform; the tendency to harden or soften with variations of temperature being almost entirely obviated. The improvement in printing, herein described, as resulting from the use of the vulcanized India-rubber, will be principally experienced in the printing of woolen, cotton, and similar fabrics; but it will also be experienced in a great degree in the letter-press, lithographic, copper-plate, and other printing processes, where a woolen or other blanket, or elastic bed, is commonly used.

The second part of the invention consists in the application of an apparatus to the ordinary printing machine for cleaning the said vulcanized India-rubber web, or blanket, or bowl, by which the use of gray or unfinished pieces of calico, &c., commonly employed for keeping the ordinary printing blanket clean, is dispensed with, and a great saving of steam in drying, and power in turning, is effected, a finer impression is obtained, and the machine made more compact, in consequence of the ordinary drying and blanket rollers being removed. When this improved web or blanket is employed for calico or similar printing by the common machines, the web or blanket to be formed of vulcanized India-rubber should be about seven-eighths of a yard wide (or of any other convenient width, as required), and from four to six yards long, evenly joined at the ends; and as the joining of the ends of the web has to be effected before the process of vulcanizing, one side of the machine will require to be moved to admit

* Patented in April, 1845.

the blanket upon the printing-bowl; it is then passed over a frame, of which a sketch is exhibited in fig. 31, and which may be applied above the printing-machine, in place of the ordinary blanket-rollers:—A, is the first drawing-roller, made of copper, turned quite true; the web or blanket, B, in passing over this, comes in contact with the doctor, C, formed of a stiff bar of brass, with a flat edge towards the blanket, and a sloping edge on the other side, and having a small trough to receive the color scraped from the blanket; it then passes downwards in front of a friction-roller, D, over which a short endless blanket or web, E, E, (also of vulcanized India-rubber or other suitable material) works, and in an opposite direction to the printing blanket, B; the roller, D, being fluted, and the web, E, drawn tight over it, and set against the printing-blanket by means of the screw. The roller then acts as a circular doctor, scraping and drying any color that may have passed the first doctor, which color is conveyed along the web, E, E, over the roller, G, when it comes in contact with another doctor, F, by which the color is ultimately removed; the printing-blanket then passes over a steam-drying cylinder, H, and to remove any damp that may remain over the tension-roller, I, and then returned to the printing-roller, J.

Fig. 31.



The third part of the invention consists in the novel and peculiar construction of what is termed in printing a *sieve-roller;* the important feature of novelty in which, *is the elasticity imparted to such roller by the medium of air*, confined between the outer covering and inner body of such sieve-roller. These rollers are employed for transferring color to surface-rollers or copper printing rollers, in printing woolen or cotton goods by machines. The improved sieve-roller is formed of an iron centre, about one and a half inches in diameter, and about thirty-two inches long (according to the machine it may be required for), with two flanges about five

inches in diameter grooved on the edge to the depth of half an inch,—the flanges to be fitted on to the width required for the goods intended to be printed. Twenty-eight inches will be found amply wide enough for seven-eighths cloth; but care must be taken that the flanges are fitted on so as to be air-tight, and a tap for admitting air must be screwed into one of the flanges. The grooves are fitted with strips of sheet India-rubber, moistened with turpentine, and wound on until level with the edge of the flanges: the space between the flanges being filled with soft flannel evenly wound on to the level of the flanges. A sheet of India-rubber made in the form of a pipe or cylinder is then made to fit the flanges, and it is drawn over so as to form a covering for the roller (it having been previously dusted in the inside with powdered French chalk, to cause it to slip easily); the ends are joined to the rubber in the grooves by moistening with turpentine. The roller must be covered with a sheet of gauze or cotton cloth coated with caoutchouc, which is intended to prevent the India-rubber from distending when inflated, and for fixing on the rings for keeping the colors separate, when used for printing more than one color; the rings are cut from a sheet of rubber about a quarter of an inch thick, and to the length required to go around the roller; one edge to be the thickness of one-eighth of an inch, and the other tapering; they may be made to adhere by wetting the edge with turpentine and applying it to the gauze: the woolen sieve or strips are then sewed on for printing. The elasticity of this sieve-roller may be varied by regulating the quantity of air confined under the outer surface of the roller.

The fourth part of this invention consists in the application of a covering of spongy or porous vulcanized rubber, placed on a centre or axis of iron or wood, to be used as a roller for furnishing surface or copper-printing rollers with color; and also the applying of India-rubber rings or divisions, made by strips of rubber being attached to the surface of ordinary woolen or other sieves, for surface-printing, by which means various colors may be printed at the same time, both in "pegging" and "rainbowing." In forming the rollers from

the spongy vulcanized rubber, a cylinder or tube made of the material, at least one inch thick, and of the size required, is drawn over a wooden or iron centre, to fit the diameter of the roller, the same as the elastic or air-roller before described.

CHAPTER V.

CALICO-PRINTING PROCESSES.

THE MADDER, PADDING, AND RESIST STYLES.

We observed, on a former occasion,* that we should give everything of any practical value, on calico-printing processes, in this and the following chapter, to be found in Parnell's "Applied Chemistry," and Ure's "Dictionary of Arts, Manufactures, and Mines," and in a more convenient form, at least for any practical purpose. We will now proceed to the performance of that promise.

For the gratification of such as are not acquainted with calico-printing processes, we would state, that there are several different styles of work, each requiring different methods of manipulation.

I. *The madder style*, to which the best chintzes belong, in which the mordants are applied to the white cloth with many precautions; the colors being afterwards brought up in the dye-bath. On those portions of the cloth on which the mordant is applied, the coloring matter attaches itself in a durable manner, but on the unmordanted portions the color is feebly attached, so that it may be wholly removed by washing either in soap and water, in a mixture of bran and water, or in a dilute solution of chloride of lime.

II. *The padding style*, in which the whole surface of the calico is imbued with a mordant, upon which afterwards different colored figures may be raised, by the topical application of other mordants joined to the action of the dye-bath. To produce a figure in a mineral coloring material, the cloth may

* See chapter II, of this Part, page 466, note.

be first printed with one of the two saline solutions, and be afterwards uniformly impregnated with the other. To obtain a ground of a mineral color, one or both of the solutions may be applied by the padding machine.

III. *The resist style*, where the white cloth is impressed with figures in resist paste, and afterwards subjected to a cold dye, such for example, as the indigo vat, and then to a hot dye-bath, with the effect of producing white or colored spots upon a blue ground. Resists are divisible into two classes; one is employed to prevent the attachment of a mordant, and the other that of a coloring matter.

IV. *The discharge style.*—The object of the processes belonging to this style of work, is the production of a white or colored figure on a colored ground. This is effected by printing on the cloth already dyed or mordanted, a substance called the *discharger*, which has the property of decomposing either the coloring matter or the mordant. Chlorine and chromic acid are the common discharging agents for decomposing a vegetable or animal coloring matter, and an acid solution for a mordant.

V. *The China blue style;* a style resembling blue stoneware, which requires very peculiar treatment, and is practised with one coloring matter only, namely, indigo.

VI. *Steam Colors.*—This style combines a degree of brilliancy with solidity of color, which can hardly be obtained in any other way except the chintz dyes.

I. THE MADDER STYLE; called by some dip colors. The true chintz patterns belong to it; they have from five to seven colors, several of which are grounded-in after the first dye has been given in the madder-bath. In dyeing with madder, sumac, fustic, or quercitron, is sometimes added to the bath, in order to produce a variety of tints with the various mordants at one operation.

1. Suppose it be wished to produce figures containing red, purple, and black, the three mordants may be applied at once by the three-color cylinder machine, putting into the first trough acetate of alumina thickened; into the second, acetate of iron; and into the third, a mixture of the two; then dry-

ing in the air for a few days to fix the iron, dunging and dyeing in a bath of madder and sumac. If it be wished to procure the finest madder reds and pinks, besides the purple and black, acetate of alumina of two densities must only be applied first by two cylinders, dry, dung, and dye in a madder bath.* The mordant of iron liquor for the black, and of iron liquor mixed with the aluminous for purple, must be now grounded-in by blocks, taking care to insert these mordants in their proper places: the goods being then dried with airing for several days, and next dunged, are dyed in a bath of madder and sumac. They must be afterwards cleared by branning.

2. Suppose it be wished to produce yellow with red, pink, purple, and black; in this case the second dye bath should contain quercitron or fustic, and the spots intended to be yellow should receive the acetate of alumina.

3. The mordant for a full red may be acetate of alumina,† of spec. grav. 1·055, thickened with starch, and tinged with Brazil-wood; that for a pale red or pink, the same at spec. grav. 1·014, thickened with gum; that for a middling red, the same at spec. grav. 1·027, thickened with British gum; and for distinction's sake, it may be tinged yellow with Persian berries. The mordant for black is a pyroligneous acetate of iron, of specific gravity 1·04; for purple the same, diluted with six times its volume of water; for chocolate, the iron liquor mixed with acetate of alumina, in various propor-

* To obtain on cloth the finest madder reds, purple, and black, it is sometimes better first to print on only the aluminous mordants for the reds, by the two or three-color machine, and then to age, dung, and madder. The strong iron liquor for black, and the weaker iron liquor for purple, may be next grounded in their proper places by hand-blocks, after which the drying, dunging, and maddering are repeated. Sometimes the mordants are printed on at different operations, but the dyeing is performed in one bath. For example, the mordant for black is printed on first by the single-color machine, after which the cloth is aged for a day or two; the mordants for the other colors are then grounded-in by the hand-blocks, and the ageing, dunging, dyeing, &c., are performed in the usual manner. An endless variety of tints, from red to chocolate, may be obtained from the same madder bath, by mixtures of the iron and aluminous mordant in different proportions.—*Parnell.*

† See chapter I, Part III.

tions, according to the shade wanted. Sumac is mixed with the madder for all these colors except for purple.*

4. In the grounding-in for yellow, after madder reds, the aluminous mordant being applied, &c., the piece is dyed, for about an hour, with one pound of quercitron bark, the infusion being gradually heated to 150° or 160°, but not higher.

A yellow is sometimes applied in chints work after the other colors have been given, by means of a decoction of Persian berries mixed with the aluminous mordant, thickened with flour or gum, and printed-on with the block; the piece, when dry, is passed through a weak carbonated alkaline water, or lime water, then washed, dried, and finished for the market.

Quercitron is another dyeing material well adapted for the madder style of work. With a mordant of red liquor of spec. grav. 8° or 12° Twad., thickened with starch, it affords a bright yellow; with iron liquor spec. grav. 2° or 3° Twad., thickened with starch, an olive-gray; and with a mixture of the iron and aluminous mordants, a great variety of yellowish-olive tints. To produce a yellow ground with quercitron, the cloth may be padded in red liquor of 10° Twad., and after being dried, aged for two days, and winced in warm chalky water, may be dyed in an infusion of quercitron, containing a little glue or size. To get a yellowish olive figure from the same infusion, the cloth may be printed with a mixture of red liquor at 11°, and iron liquor at 5° Twad., in equal measures, and then dried, aged, dunged, winced in chalky water and dyed.

5. *Grounding-in of Indigo blue.*—

Take half a gallon of water at 120° F., 8 ounces of indigo, and 8 ounces of red sulphuret of arsenic (orpiment), 8 ounces of quicklime, mix together, and heat the mixture to the boiling point; draw the fire, and add, when lukewarm, 6 ounces of carbonate of soda, stir and let rest till the next day. Then decant the clear liquor, and thicken every quart of it with half a pound of gum.

This color should be green, and preserved in a close vessel. When used, it is put into a pot with a narrow orifice, the

* A beautiful orange is obtained by a mixture of decoction of cochineal and decoction of quercitron, with an aluminous mordant; and fine lilacs and violets by decoctions of logwood and of cochineal, with the same mordant.

pencil is dipped in, wiped on the edge of the pot, and immediately applied by hand. This plan is tedious, and is nearly superseded by the following grounding blue :—

Take half a gallon of caustic soda ley of spec. grav. 1·15, heated to 120° F.

12 ounces of hydrate of protoxide of tin, *obtained by precipitating it from the muriate of tin by solution of potash.*

8 ounces of ground indigo; heat these mixed ingredients to the boiling point, then move the pot off and on the fire two or three times in succession, and finally thicken with three pounds of raw sugar.

Fig. 32.

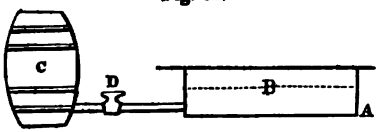
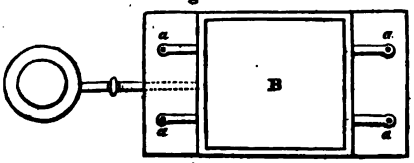


Fig. 33.



In order to apply this by the block, the following apparatus is employed, called the *canvass frame ;* figs. 32 and 33. It is formed of a copper case or box, A, in which is laid a frame, B, filled with pretty stout canvass. The box communicates by a tube with the cistern, C, mounted with a stop-cock, D. Fig. 33 represents the apparatus in plan : A, the box ; B, the canvass, with its edges, *a*, *a*, *a*, *a*, fixed by pin points to the sides. The color is spread even, with a wooden scraper as broad as the canvass. In working with this apparatus, the color contained in the vessel, C, is drawn off into the case, A, by opening the stop-cock, D, till it rises to the level of the canvass. The instant before the printer daubs the block upon the canvass, the scraper is run across it to renew its surface ; and the printer immediately transfers the color to the cloth. In this kind of printing great skill is required to give uniform impressions. As the blue is usually applied to large designs, it is apt to run ; an inconvenience counteracted by dusting fine dry sand upon the cloth as soon as it is blocked. The goods must be washed within 24 hours after being printed.

6. *Topical grounding blue for the cylinder press.*—

Take 3½ gallons of caustic soda ley of spec. grav. 1·15.

3½ lbs. of indigo.

5 lbs. of precipitated protoxide of tin.

Boil the mixed ingredients for ten minutes, take from the fire, and add, first 3 lbs. of Venice turpentine; then 11 lbs. of gum.

Put this mixture into the color trough, print with it, and after two days wash in the dash-wheel; then pass through a soap bath, with a little soda, to brighten the color and to drive off its grayish tint.

The use of the turpentine is easily explained; it serves to exclude the atmospherical oxygen, and prevent the regeneration of the indigo blue, before it is spread upon the cloth. After the application to white calico of a similar blue, into which a little acid muriate of tin has been put, the goods are dipped for ten minutes in thin milk of lime, shaking the frame all the time. They are then washed, and cleared with a soap boil.

7. *Topical Prussian blue for grounding.*—

2 quarts of water with 8 ounces of starch are mixed and boiled; add 2¼ ounces of a liquid Prussian blue, prepared by triturating three quarters of an ounce of the pigment with as much muriatic acid, leaving the ingredients to react upon each other for 24 hours, and then adding three quarters of an ounce of water. Add 4 ounces of liquid perchloride of tin (oxymuriate). Mix all together, and pass through a searce.*

8. *Prussian blue figures* are impressed as follows:—

Dissolve 8 ounces of sulphate of iron, and as much acetate of lead, separately, in 2 quarts of boiling water; mix well, and let settle. Take 1 quart of this liquor reduced to spec. grav. 1·02, 1 quart of mucilage containing 3 pounds of gum, colored with a little prussiate of potash, mix into a mordant, and print it on with the cylinder. Two days afterwards wash in tepid water containing a little chalk, and then pass the cloth through a solution of prussiate of potash in water, sharpened with a little muriatic acid, till it takes the desired hue. Rinse and dry.

When black is one of the colors wanted, the mordant is very commonly printed on first, and the goods hung upon poles in the drying-room, where they are aired for a few days, in order to fix the iron by its peroxidizement; the mordants for red, violet, &c., are then grounded in, and the pieces dyed, after dunging and washing, in the madder bath, into which, for certain shades, sumac, galls, or fustic is added. The goods are brightened by a boil in soap water; occasion-

* This color is not very fast; cloth printed with it will bear only rinsing.

ally also in a bath, containing a small quantity of solution of tin or common salt. The following mode of brightening is much extolled by the French, who are famous for their reds, roses, &c. :—

1. A soap boil of forty minutes, at the rate of one pound for every two pieces.

2. Pass through chloride of soda solution, of such strength that two parts of it decolor one part of Gay Lussac's test liquor.* Wince the pieces through it for forty minutes. Rinse.

3. Pass again through the soap bath, No. 1.

4. Brighten in a large bath of boiling water, containing 4 pounds of soap, and 1 pound of a cream-consistenced salt of tin, containing nearly half its weight of the muriate of tin, combined with as much nitric acid of spec. grav. 1·288. This strong nitro-muriate having been diluted with a little water, is to be slowly poured into the soap bath, and well stirred. The pieces are now put in, and winced for half or three quarters of an hour.

5. Repeat the soap boil, No. 1. Rinse and dry.

A very good orange is sometimes communicated to cotton goods in this style of work, by dyeing in a mixed infusion of madder and quercitron, an aluminous mordant having been previously applied to the cloth. For a ground, the cloth may be padded in red liquor of 10° or 12° Twad., then winced in warm chalky water, and dyed in a decoction of two pounds of quercitron and a pound and a half of madder per piece. By varying the proportions of the madder and quercitron various shades of orange from *golden-yellow* to *scarlet* may be produced. An endless variety of cinnamon, olive, and fawn colored tints may also be obtained by applying mixtures, in various proportions, of red liquor and iron liquor, and by dyeing in a mixed infusion of madder and quercitron.

6. *Violet mordants.*†—These consist either of a very weak solution of acetate of iron of specific gravity 1·007, for example; or of a little of the stronger acetate of 1·04, mixed with acetate of alumina, and a little acetate of copper, thickened with starch or British gum. The shades may be indefinitely varied by varying the proportions of the acetates.

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* See chapter I, Part II.

† *Puce mordant.*—Take a quart of acetate of alumina and acetate of iron, each of spec. grav. 1·04, mixed and thickened like the black, No. 6. To give the puce a reddish tinge, the acetate of alumina should have a specific gravity of 1·048, and the iron liquor only 1·007.

7. *Black mordant.*—

Take half a gallon of acetate of iron, of spec. grav. 1·04, 4 ounces of starch, and 4 ounces of flour. The starch must first be moistened with the acetate, then the flour must be added, the rest of the acetate well mixed with both, and the whole made to boil over a brisk fire for five minutes, stirring meanwhile to prevent adhesion to the bottom of the pot. The color must be poured into an earthen pipkin, and well mixed with half an ounce of gallipoli oil. In general, all the mordants, thickened with starch and flour, should be boiled for a few minutes. With British gum or common gum, they must be heated to 160° F., for the purpose merely of dissolving them. The latter should be passed through a sieve to separate the impurities often present in common gum.*

II. THE PADDING STYLE.—Any mordant whatever, such as the acetates of alumina, or of iron, or their mixture, may be applied to the piece by the padding machine, after which it is dried in the hot flue, washed, dunged, dyed, washed, and brightened.

Mineral coloring matters are adapted, not only to the production of designs on a white or colored ground, but also to form a ground for the reception of a design in other colors. To impart the color to the entire surface of the cloth, the latter may be impregnated successively, by the padding machine, with the two solutions necessary to produce the color, or the cloth may be padded in one of the solutions and afterwards winced in the other. To produce a design in a mineral coloring matter on a white or colored ground, the cloth is usually first printed with one of the solutions, and then either padded or winced in the other.

1. *Chrome-yellow.*—Yellow and orange are produced by the two chromates of lead, chrome-yellow and chrome-orange.

To impart a ground of chrome-yellow, the cloth should be padded with a solution of two pounds of acetate of lead in a gallon of water containing a little size, then dried, passed first through a weak solution of carbonate of soda, and afterwards through a solution of bichromate of potash. Rinse and dry.

* To produce a black ground, the cloth may be padded in a mixture of equal measures of red liquor at 8° Twad., and iron liquor at 6° Twad., and after having been dried, aged, and winced in chalky water, it may be dyed in a decoction of logwood made from two pounds and a half or three pounds per piece, with the addition of a small quantity of sumac. A grey color is obtained in the same way by using very weak iron liquor and a weak decoction of the coloring matter; and a violet color, by applying weak red liquor to the cloth.—*Parnell.*

To apply chrome-yellow, the cloth may be printed with a solution containing both acetate and nitrate of lead (from seven to ten ounces of each to the gallon) thickened with starch. After being printed and dried, the cloth is winced first in a weak solution of carbonate of soda, and next in a solution of bichromate of potash, containing about two ounces per piece. To clear the whites, the cloth may be winced in water slightly acidulated with muriatic acid.*

2. *Prussian blue.*—To impregnate the entire surface of a piece of cloth with Prussian blue, it may be treated in the following manner:—

1. Pad in a solution of acetate and sulphate of iron made by adding three pounds of acetate of lead to a solution of four pounds of copperas in a gallon of water, decanted from the precipitated sulphate of lead and diluted to the density 2° or 3° Tw.
2. Dry and wince in warm chalky water.
3. Wince in a solution of a pound of yellow prussiate of potash in forty gallons of warm water, to which add four ounces of oil of vitriol.

To produce a design in Prussian blue by this style of work, the cloth may be printed with a mixed solution of acetate and sulphate of iron, made as above, of spec. grav. 4° or 5° Tw., thickened with gum and "sightened" by the addition of a little prussiate of potash. Age, wince in chalky water, clean, and wince until the desired shade is obtained, in a solution containing three or four ounces of prussiate of potash, and one ounce of muriatic acid per piece.

Chrome-orange.—A ground of chrome-orange may be communicated to a piece of cotton by first applying chrome-yellow in the ordinary manner, and exposing the cloth to boiling lime-water, which withdraws a portion of the chromic

* *Chrome-yellow.*—Pad in a solution of bichromate of potash containing 8 ounces to the gallon of water; then dry with moderate heat, and pad in a solution of acetate or nitrate of lead, containing 6 or 8 ounces to the gallon of water; wash, and dry. Or pad first in a solution of acetate of lead containing a little glue; dry, and pad in solution of bichromate of potash. Then rinse. The last process is apt to occasion cloudiness. To obtain a light lemon tint, pad in a solution of acetate of lead of double the above strength, or 16 ounces to the gallon, then wince the pieces through weak milk of lime, rinse, pad through bichromate of potash, rinse and dry.—*Ure.*

acid from the chrome-yellow and leaves chrome-orange: thus,

1. Pad the cloth twice in a saturated solution, in water, of acetate and nitrate of lead; in the proportion of a pound of nitrate to a pound and a quarter of acetate.* Dry in the hot flue.

2. Wince in weak milk of lime for a few minutes.

3. Wince in a warm solution of bichromate of potash containing five or six ounces per piece.

4. Wince in boiling milk of lime. Rinse and dry.

To produce a design in chrome-orange on a white ground, print with a saturated solution of acetate and nitrate of lead (as above) thickened with British gum; dry, and pass through a solution of sulphate of soda to fix the oxide of lead in an insoluble state, wash well in water, and wince in a warm solution of bichromate of potash. Rinse, and pass through boiling milk of lime to convert the chrome-yellow into chrome-orange.

A design in chrome-yellow, on a chrome-orange ground, may be obtained by printing an acid on the orange ground, to withdraw the excess of oxide of lead from the subchromate (orange), and thus form the neutral chromate (yellow).

Different shades of green may be given by a mixture of chrome-yellow with Prussian blue. The cloth is first padded with a mixture of acetate of iron and nitrate of lead, and winced in a solution of prussiate of potash and bichromate of potash with a small quantity of muriatic acid.

To obtain a green design by conjoining chrome-yellow with indigo-blue, print with a solution of from two pounds to two pounds and a half of nitrate of lead, in a gallon of neutralized mixture of white indigo with solution of tin. After printing, pass, first, through a warm solution of carbonate of soda, to fix the blue and oxide of lead, and then through a solution of bichromate of potash to raise the yellow.†

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* Water is capable of dissolving nearly twice as much of a mixture of acetate and nitrate of lead, in the proportion of single equivalents, as of either of the salts separately.—*Parnell.*

† *Chrome Orange.*—Pad through a mixed solution of the subacetate and acetate of lead, three times in succession, and dry in the hot-flue; then wince for ten min-

Green is given by padding goods, previously dyed in the indigo vat, in a solution of acetate of lead containing a little glue; and then padding them in a warm solution of bichromate of potash; finally rinsing and drying. To obtain a ground of Scheele's green, (arsenite of copper,) pad two or three times with a solution of nitrate of copper, or with a mixture of the sulphate and acetate containing a little size, and after drying, wince in a dilute solution of a caustic alkali, to fix the oxide of copper. The cloth is next rinsed in water and winced in a dilute solution of arsenious acid, or in a solution of arsenite of soda.

Mineral colors are frequently combined with steam and madder colors in the same design. When this is the case, the madder colors should be applied first, the mineral colors next, and the steam colors last. The following method of procuring a design in black, purple, two shades of red, two shades of buff, green and yellow, on a white ground, is an example of the combinations of mineral colors with madder and steam colors:

1. Print the cloth by the four-color machine with the mordants for black, purple, and two reds;
2. Age, dung, dye in the madder bath, clear and dry;
3. Print with the two-color machine (or with blocks, according to the design) with buff-liquor of two strengths, thickened with starch or British gum;
4. Age, and wince in milk of lime, to raise the buff; then rinse in water;
5. Dry and print with blocks with mixtures for steam blue, and steam yellow.
6. Age, steam, and rinse.*

Copper green is given by padding in a mixed solution of sulphate and acetate of copper with a little glue, drying in the hot flue, and next day padding in a caustic ley of spec. grav. 1·05. The goods are then rinsed, and padded through a solution made with 8 ounces of arsenious acid combined with

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utes through weak milk of lime; rinse; wince for a quarter of an hour in a warm solution of bichromate of potash; and finally raise the color by wincing the goods through hot lime-water.—*Ure.*

* A pleasing pattern may be obtained by combining in one design, on a white ground, figures or bars, in different shades of iron buff, with a figure or stripe in steam blue. The buffs are first applied in the usual manner.

4 ounces of potash diluted with 2 gallons of water. Rinse and dry.*

Iron buff.—The solutions of iron in common use for iron buff are the pernitrate and a mixture of the acetate with the protosulphate, obtained by adding from one to three parts of acetate of lead (pyrolignite) to three parts of copperas. Double decomposition takes place between the acetate of lead and a portion of the copperas, with formation of acetate of iron and sulphate of lead. For light shades, alum is sometimes added, together with a little carbonate of soda to take up a portion of the acid of the alum. Acetate of lime is frequently substituted for acetate of lead, in the preparation of "buff-liquor."

To impart a buff ground, the pieces are padded in a liquor of any strength between 2° and 10° Tw., according to the shade desired, then dried by being drawn either through the hot-flue or over iron boxes filled with steam, and aged for one or two days. Some printers then wince the pieces in water containing a little chalk, and afterwards pass through a solution of carbonate of soda; but it is better to pass them at once through a solution of caustic soda, or through milk of lime.

During the ageing of the padded goods the salts of the protoxide of iron become subsalts of the peroxide, which are decomposed in the alkaline or calcareous solutions, the acids being withdrawn by the alkali while the peroxide of iron becomes fixed on the cloth.

To obtain an iron buff figure, the pieces may be printed with a buff liquor of any strength between 10° and 30° Tw.,†

* Olive and cinnamon colors are given by padding through mixed solutions of the acetate of iron and sulphate of copper; drying, and padding in a caustic ley of spec. grav. 1·05.

† *Iron buff.*—Take 50 gallons of boiling water; 150 pounds of sulphate of iron; dissolve along with 10 pounds of alum; which partly saturate by the gradual addition of 5 pounds of crystals of soda; and in this mixture dissolve 50 pounds of pyroligneous acetate of lead. Allow the whole to settle, and draw off the clear supernatant liquid. For furniture prints this bath should have the spec. grav. 1·07. The goods being padded in it, are dried in the hot-flue; and after 48 hours suspension are to be washed in water at 170° containing a little chalk, by the

thickened with either gum, calcined farina, salep, or British gum. After being dried and aged, the pieces are passed directly through a solution of caustic soda, or milk of lime.

Manganese bronze.—A brown ground may be produced by manganese bronze or peroxide of manganese. A solution of manganese sufficiently pure for producing the bronze, may be obtained from the residue of the process for chlorine, by saturating the remaining free sulphuric or muriatic acid with chalk, allowing the precipitate to settle, and decanting and concentrating the clear supernatant liquid. The chalk serves not only to saturate the free acid, but to precipitate peroxide of iron from the soluble salts of that oxide which this bye-product always contains. Lime has been recommended for this purpose instead of chalk, but it is never employed on the large scale, as an excess would decompose the salts of manganese as well as those of iron; an excess of chalk, however, is without action on the manganese salt. A purer solution of manganese may be prepared by heating the residue of the chlorine process with more black oxide of manganese, until the evolution of chlorine almost ceases, and then adding, either chalk, or freshly precipitated carbonate of manganese, until the liquid becomes colorless. Having been allowed to settle, the solution is decanted and concentrated by evaporation.

To impart a dark bronze ground, the strength of the solution of the chloride of manganese may be about 26° Twad. For lighter shades it may be made as weak as 4° Twad.

After padding* and drying, the goods are passed through a

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wince. The goods are then washed, by the same apparatus, in hot water, containing a pailful of soda ley of spec. grav. 1·04. For light tints the padding liquor should be reduced to the spec. grav. 1·01. The dye in either case may be brightened by wincing through a weak solution of chloride of lime. Nitrate of iron diffused through a body of water may be also used for padding, with alternate washings in water, and a final wincing in a weak alkaline ley. With a stronger solution, similar to the first, the boot-top color is given.—*Ure.*

* *Manganese Bronze.*—The goods are padded in a solution of the sulphate or muriate of manganese, of a strength proportional to the shade desired, dried in the hot-flue, and raised by wincing in a boiling hot caustic ley, of spec. grav. 1·08, and next passed through a weak solution of chloride of lime, or soda, and rinsed. In-

cold caustic ley, whereby protoxide of manganese becomes precipitated on the cloth. On exposure to the air, the protoxide soon absorbs oxygen, passing into the state of the brown peroxide; but the peroxide may be produced immediately by wincing the goods in a solution of chloride of lime or chloride of soda, as soon as taken out of the caustic ley. The common practice is to expose the pieces to the air until they acquire a good full color, and then to complete the peroxidation of the manganese by a dilute solution of chloride of lime.

Peroxide of manganese is very seldom applied as a figure on a white ground. The solution of the chloride used for this purpose may have a density of about 16° Tw., and be thickened with from two to two and a half pounds of gum to the gallon. A small quantity of tartaric acid is a useful addition to such a solution. The cloth, when printed and dried, is drawn through a caustic ley, exposed to the air, and winced in a solution of chloride of lime.

III. THE RESIST STYLE.—The object of the resist style of work is to produce a white or colored design on a colored ground by the topical application, in the first place, of a substance called *resist paste*, which has the property of preventing the attachment of color, when the whole surface of the cloth is afterwards impregnated with a dyeing material. One class of resists, consisting of substances of an unctuous nature, acts merely mechanically; another both mechanically and chemically. The latter kind are divisible into two subdivisions, according as their influence is exerted on the mordant or on the coloring matter itself.

1. *Fat Resists.*—Resists of an unctuous nature are chiefly used for silken and woolen goods, but they may be also advantageously applied, in particular circumstances, to goods

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stead of passing the goods through the chloride, they may be merely exposed to the air till the manganese attracts oxygen, then rinsed and dried. When the manganese solution has the density of 1·027, it gives a light shade; at the density of 1·06, a shade of moderate depth, and at 1·12 a dark tint. The texture of the goods is apt to be injured during the oxidation of the manganese. *Carmelite* is obtained by padding in a mixture of muriate or sulphate of manganese and acetate of iron. —*Ure.*

of cotton; as in the combinations of such a style of work with madder colors and steam colors. In an early stage of the process, after having been printed, dyed, and cleared, the red and lilac figures are covered with a resist consisting, usually, of a mixture of suet and gum-water. The whole is then run over by the roller with weak iron liquor for the lilac ground; the cloth is then aged, dunged, dyed, and cleared.

The mixtures for steam green and steam yellow are afterwards put on by blocks; the steaming being performed in the usual manner. In this style of work, the dyeing with madder might as well be performed at one operation, as the red lilac mordants are not at all injured by the fat resist with which they are covered.

2. *Resist for Mordants.*—The material generally used for preventing the deposition of a mordant on particular parts of the cloth is an acid or acidulous salt capable of uniting with the base of the mordant, to form a compound soluble in water and not decomposable into an insoluble subsalt during the hanging of the mordanted goods, previous to dunging and dyeing. The resist commonly employed for the iron and aluminous mordants is lemon-juice or lime-juice, or a mixture of one of these with tartaric and oxalic acids and bisulphate of potash. The thickening material is either a mixture of pipe-clay or china-clay with common gum, a mixture of British gum with gum senegal, or British gum alone. Lemon-juice or lime-juice is decidedly preferred to pure citric acid (which is the acid principle of these juices), as the mucilaginous matters in the former impede the crystallization of the acid within the pores of the cloth, and thus render it better adapted to prevent the attachment of the mordant in an insoluble form.

A design in black, lilac and white on a lilac ground, may be produced by adapting the resist style of work to madder colors. The printing for such a pattern may be performed by the three-color machine in the following order:—

By the first roller; the resist, which may be either lemon-juice of spec. grav. 2° or 3° Twad., thickened with four pounds of British gum to the gallon, or a solution of about the same density, of tartaric and oxalic acids in weaker lemon-juice, also thickened with British gum:

By the second roller; the mordant for the black (iron liquor of spec. grav. 8° Twad.) thickened with a pound and a half of flour to the gallon:

By the third roller; the mordant for the ground of lilac (iron liquor of spec. grav. 1½° Twad.), thickened with four pounds of British gum to the gallon.

The application of the mordant for the ground may be made by the padding machine, but it is more commonly done by the cylinder machine, the entire surface of the copper roller being slightly roughened or engraved in close diagonal lines to enable it to afford an uniform deposit on the cloth.*

Iron liquor may be resisted or prevented from affording a deposit of insoluble subsulphate during the ageing, by a process somewhat different from that just described, the resisting agent being protochloride of tin (generally called salts of tin), instead of a free acid or an acidulous salt. A mixture of protochloride of tin and iron liquor does not afford a deposit of a subsalt of iron during the ageing of goods printed with the mixture, probably through the occurrence of a double decomposition, with formation of acetate of tin and chloride of iron. The latter compound does not afford an insoluble precipitate during the ageing, and may be entirely removed from the cloth by washing.

When a piece of cotton cloth is printed with a solution of salts of tin by the first roller of a two-color machine, and with iron liquor by the second roller, over the parts printed by the first roller, such a mixture as the above is of course formed wherever the salt of tin had been applied, and no subacetate of iron is deposited there during the ageing.

The protochloride of tin, however, is never applied in this way with a view of producing a white figure on a colored ground; it is commonly mixed with red liquor, as the deposition of the insoluble subsulphate of alumina from that preparation is not interfered with by the protochloride. After a piece of cloth thus printed has been aged, dunged, dyed in the madder-bath, and cleared, it therefore presents a red figure

* The operations of ageing, dunging, dyeing, and clearing, are conducted in much the same manner as if the acid resist had not been applied. It is usual, in this style of work, to add a small quantity of chalk to the dung-bath, in order to counteract the effects of the free acid in the resist.—*Parnell.*

surrounded by purple or lilac. It should be observed that this method of procedure is only followed when a better definition of the red design is required than could be attained by leaving a blank figure in the roller for the iron liquor, and afterwards printing the red liquor on the white parts either by a second roller or by the block. To resist weak iron liquor and impart the mordant for a full red with madder, the mixture may have the following composition :—

1 gallon of red liquor of 18° Twad.,
4 oz. crystals of protochloride of tin; with a sufficient quantity of British gum or a mixture of the gum and starch as the thickener.

To obtain a design in full red and black on a lilac ground, print with a strong iron liquor for the black, with the above mixture for the red, and with iron liquor of 1° Twad. for the lilac; after which the goods are aged, dunged, dyed, &c. in the usual manner. A great variety of pleasing effects may be produced by combining this kind of work with steam or topical colors, the iron liquor not being applied as a ground, but as a design extending on each side of the red figure, and on the parts left white the steam colors are applied, after dyeing with madder and clearing.

Another material, much used as a resist for red liquor and iron liquor, is a solution of citrate of soda, *prepared by neutralizing lime-juice of about* 4° *Twad. with soda, thickened with a mixture of gum and pipe-clay.* The action of this resist may probably be referred to the tendency of citric acid, like oxalic acid and a few others, to form a double salt with peroxide of iron or alumina and an alkali, which affords no precipitate of alumina or oxide of iron during the ageing. In this case a portion of the alkali in the neutral citrate is withdrawn by the acetic acid in the mordant, an acid citrate of soda being thus formed. Neutralized lime-juice of 4° Tw., has about the same resisting power as the unneutralized juice of 2° Tw.

The principal use of neutralized lime-juice as a resist for iron liquor is to protect figures previously applied in madder colors; for which purpose the free acid is quite inapplicable,

as it would dissolve the mordant on the cloth in combination with the coloring matter.

3. *Resists for the coloring matter.*—The production of a white or colored pattern on a colored ground by the direct action of a resist on a coloring matter, is chiefly practised with indigo, at least in the printing of calicos. The substances most commonly employed for this purpose are salts of the black oxide of copper, particularly the sulphate and the acetate. Sulphate of zinc is also extensively used.

The ordinary course of operations practised in this style of work, with the view of producing merely a white pattern, are the following :—

The resist, mixed with unctuous matters and properly thickened, is first printed on such parts of the cloth as should not absorb the indigo; the goods are then suspended for one or two days (according to the composition of the resist) in a chamber at common temperatures, and not very dry. The pieces are then framed and dipped into the indigo vat. The solution is immediately absorbed on all parts where the resist had not been printed, which parts become deep blue when the cloth is afterwards exposed to the air, the soluble indigotin passing into the state of insoluble indigo-blue through the absorption of oxygen.*

A white pattern on a blue ground may be produced by the blue vat, by mixing 100 pounds of ground indigo, 135 pounds of copperas, 175 pounds of lime, and from 1,600 to 2,000 gallons of water. The vat is fit for use two days after the materials are mixed. For a deep blue, the cloth is dipped into the vat for ten minutes and then exposed to the air for the same length of time; the dipping and exposure to the air are repeated until the required shade is obtained.

The composition of the resist paste is varied according to the depth of color in the blue ground. The following mixture is well adapted for dark blue :—

No. 1.

3 to 4 pounds of sulphate of copper,
7 pints of water,
5 pounds of pipe-clay, china-clay, or sulphate of lead,
4 ounces of soft soap,
3 pounds of gum.

For a resist paste for light blue, the proportion of sulphate

* See chapter V., Part III.

of copper may be reduced to eight ounces in a gallon of the paste. This resist we may call No. 2.

The sulphate of zinc resist, for protecting a design in madder colors as well as for preserving some white, may have the following composition :—

No. 3.

4 to 5 pounds of sulphate of zinc,
2 quarts of boiling water,
5½ pounds of pipe-clay,
4 ounces of soft soap,
2 ounces of hogs'-lard,
2 quarts of gum-senegal water, containing 6 pounds of gum to a gallon of water.

The sulphate of zinc is first dissolved in the hot water, and with this solution, while warm, the pipe-clay, soap, and lard, are thoroughly incorporated. When the mixture is cold the gum-water is added.

Such are the methods of obtaining a white figure on a blue ground by the resist style. To procure a design in white and light-blue on a dark blue ground, the cloth is first printed with the resist (No. 1) dipped in the blue-vat and cleaned, as if a white design only is required. After being dried, it is printed with the weaker resist containing sulphate of copper (No. 2), again dipped in the blue-vat to a lighter shade, cleared in dilute sulphuric acid, and dried.

A great variety of colored designs on the same ground may also be obtained by combining with the resist, either one of the saline solutions capable of imparting a mineral color, or the mordant for a coloring matter to be applied by the madder style.

A design composed of yellow figures on an indigo ground, is very commonly and easily obtained by combining the resist with a salt of lead, and padding or wincing the cloth in a solution of bichromate of potash after being dipped into the indigo-vat and cleared. The successive operations to which a piece of calico is subjected in this kind of work are the following :—

1. Printing with the mixture of resist and salt of lead, which may have the following composition :—

1 gallon of water,
3 to 4 pounds of sulphate of copper,
1 pound of nitrate of lead,
1 pound of acetate of lead,
3 pints of a paste of precipitated sulphate of lead,
5 or 6 pounds of pipe-clay,
2 to 3 pounds of gum.

2. Hanging for one or two days in a room having a rather humid atmosphere;

3. Dipping into the indigo-vat;

4. Passing through dilute sulphuric acid;

5. Steeping in water for half an hour, and washing;

6. Wincing in a dilute solution of carbonate of soda;

7. Wincing in a solution of bichromate of potash, containing five ounces of the bichromate per piece of calico;

8. Wincing in dilute muriatic acid;

9. Washing in water.

To obtain a figure of chrome-orange instead of chrome-yellow, the calico may be first treated as above, and afterwards winced in hot milk of lime to convert the chrome-yellow into chrome-orange.

To procure a design in yellow and light blue on a dark blue ground, the cloth is submitted to the following operations:—

1. It is first printed with the mixture of sulphate of copper and salts of lead for chrome-yellow, and on the parts to be light blue with a mixture of sulphate and acetate of copper, formed by mixing solutions of acetate of lead and sulphate of copper, allowing the mixture to settle and decanting the supernatant liquid;

2. After being dried, the cloth is dipped in the blue-vat for the dark ground;

3. It is next passed through dilute sulphuric acid to clear the whites of the sub-oxide of copper, and washed in water;

4. After being winced in a mixed solution of carbonate of soda and carbonate of ammonia, it is dipped a second time into the blue-vat for the light blue of the figure, and then washed in water;

5. It is afterwards winced in a solution of bichromate of potash, and then drawn through a cistern containing a solution of one ounce of oxalic acid and as much sulphuric acid to the gallon of water.

A pattern comprising a figure of iron buff on an indigo ground, may be applied to cloth by a similar combination of the padding and resist styles, the resist (No. 1) being mixed with a salt of the peroxide of iron. After the indigo ground

is applied, the cloth is slightly washed, and then winced in a warm dilute solution of carbonate of soda to precipitate hydrated oxide of iron. A buff figure on a dark green ground is sometimes produced by first printing the cloth with the white resist, then dipping into the blue vat, and after the cloth is cleared and dried, padding it with buff liquor, and raising the buff by carbonate of soda.

Another method of producing a colored figure on the indigo ground, is by combining with the resist paste a mordant for a vegetable coloring matter, to be applied by the madder style, after the cloth has been dipped into the indigo vat. This kind of work, which is susceptible of a great variety of modifications, is distinguished as the LAZULITE STYLE, from the resemblance of the calico thus printed and dyed to the mineral *lapis lazuli*. It is also known as the NEUTRAL STYLE.

To obtain a red figure on the indigo ground, the cloth is printed with a resist paste composed, essentially, of red liquor, sulphate of zinc, and acetate of copper.

This resist may be made of the following materials, mixed in the order in which they are placed:—

No. 1.

2 gallons of boiling water,
6 pounds of alum,
4 pounds of crude acetate of lead,
4 ounces of chalk, added in small quantities at a time, and
6 ounces of sulphate of zinc.

These materials having been thoroughly incorporated, the mixture is allowed to settle, and the clear supernatant liquid decanted and mixed with acetate of copper and gum senegal, thus:

No. 2.

1 gallon of the above clear liquid,
3 ounces of acetate of copper,
18 ounces of gum senegal,
5 pounds of pipe-clay,
4 ounces of soft soap, and a little ground indigo for "sightening."

One half of the liquid is well mixed with the acetate of copper, pipe-clay, and soap, and the gum senegal is afterward added, dissolved in the other half.

After being printed with this resist, the cloth is aged for two or three days, and then subjected to the following operations :—

1. Drawing by rollers once through the blue vat at 70° Fahr.;
2. Rinsing in water;
3. Dunging or branning;
4. Washing at the dash-wheel;
5. Dyeing in the madder bath, with from two to five pounds of madder per piece;
6. Clearing by boiling first in bran water and afterwards in soap water.

To produce a light red figure with madder, the resist may have the following composition :—

4 measures of the sulphate of zinc resist paste No. 3, page 554.
1 measure of the mixture of red liquor and sulphate of zinc made as above.
1 measure of weak peachwood liquor.
1 measure of water.

For two reds the cloth may be printed with the preceding mixtures at the same time by the two-color machine, and be treated afterwards in the manner just described.

To obtain merely a small black figure on the indigo ground, the cloth may be dipped in the blue vat to the required shade, and then printed with the mixture for producing a topical black dye, such as pernitrate of iron, copperas, and extract of logwood. But if the design includes figures in red and white, the black forming a more considerable portion of the figure than a mere outline, it is better to mix iron liquor of 8° or 10° Tw. with the resist (No. 1, p. 553), and to dye the cloth in the madder bath, after having dipped it in the blue vat to the proper shade.

A great variety of purple, lilac, and chocolate tints may also be obtained on the same ground, by combining with the cupreous resist, either weak iron liquor or mixtures in various proportions of iron liquor with red liquor, and dyeing in madder after the dipping in the blue vat.

To impart to a blue ground a design in light blue, together with a color capable of being applied by the madder style, the cloth may be treated as follows :—

1. Print with the white resist, No. 1, p. 553.
2. Dip in the blue-vat, wash, wince in dilute sulphuric acid, rinse in water and dry;

3. Print the mixture of the mordant with the resist (No. 1, p. 553) on a part of the white figure produced by the first resist;

4. Dip a second time in the blue-vat, to obtain a light blue on the parts not protected by the last resist, rinse in water;

5. Dung, wash, and dye, and afterwards clear by branning.

If a white figure is required in addition to the above, the cloth is first printed with the strong white resist, dipped into the blue vat as already described, and afterwards printed on the protected parts, by the two-color machine, if the design admits, with the mixture of mordant and salt of copper, and also with a mild resist such as No. 2, p. 554. It is then dipped in the blue vat and dyed in the usual manner.

To procure a pattern containing a design in orange, crimson, and white on a blue ground, the cloth is printed by the two-color machine with the mixture of salts of copper and salts of lead (page 553), on the parts to be orange, and with a white resist on the parts to be crimson and white. After being dipped in the blue vat and cleared in dilute sulphuric acid, it is winced in the following liquids:—

1. Solution of carbonate of soda. 2. Solution of bichromate of potash. 3. Dilute muriatic acid. It is next passed through hot milk of lime to convert the chrome-yellow into chrome-orange, rinsed and dried, and is afterwards printed by the block on parts of the white with the mixture for a topical or steam red or crimson.

A pattern in blue, yellow, green, red, and white on a dark chocolate ground, may be produced *by combining the lazulite style with a topical color.* This kind of work is distinguished as the "CHOCOLATE GROUND NEUTRAL STYLE." For such a pattern the cloth is first printed (either by the machine or by the block) with the white resist,* No. 1, page 553, on all the parts required to be yellow and white, with the mixture of red liquor, sulphate of zinc, and acetate of copper, on the parts required to be red; and with a mixture of iron liquor, red liquor, sulphate of copper, and soft soap thickened with pipe-clay and gum, for the chocolate

* If a very small or well-defined white figure is required, the resist (No. 1, p. 553) should be mixed with lime-juice and sulphuric acid or bisulphate of potash, to resist the mordant in the chocolate resist, afterwards applied as a blotch. Such a mixture is designated (not very appropriately) *neutral paste.*

ground or "blotch." After having been aged for a day or two the cloth is drawn once through the indigo-vat, then washed, dunged, dyed in the madder bath, and cleared by branning. Lastly, the mixture for a topical or steam yellow is applied by the block.

A process referable to the resist style is that by which a white figure is obtained on a ground of catechue brown. On the parts to be preserved white, the cloth is printed with a solution of citrate of soda (such as that obtained by exactly neutralizing lime-juice with caustic soda) thickened with a mixture of pipe-clay and gum; or, what is preferred, a mixture of sulphate of zinc, pipe-clay, and gum. Such a resist may be printed on the cloth by one roller of a two or three color machine, and the catechue mixture by another roller, or if required, two or three shades of the brown may be applied by as many rollers. The action of both of these resist pastes is chiefly mechanical; but the sulphate of zinc also acts by precipitating the catechue in solution, and thus preventing its access to the fibre of the cloth.*

* The same resist may be employed for preventing the deposition of catechue on a colored design previously applied in madder colors.

CHAPTER VI.

CALICO-PRINTING PROCESSES.

THE DISCHARGE-STYLE, CHINA-BLUE STYLE, STEAM COLORS, ETC.

IV. THE DISCHARGE STYLE.—The manner of producing a white or colored pattern, on a colored ground, by the topical application of a "discharger" to a cloth already mordanted or dyed, is applicable to both mineral and vegetable coloring matters. Like the resist paste, the discharger may act either on the coloring matter itself, or on the mordant before the cloth is exposed to a dyeing liquid. Dischargers for mordants, are generally acid mixtures quite similar to resists for mordants, but dischargers for coloring materials are obtained from different classes of chemical substances, according to the nature of the coloring matter to be removed. The essential property required in a discharger, is that of converting the substances on the cloth into colorless or soluble products, which may be removed from the cloth so as not to interfere with the subsequent application of a coloring material to the parts discharged.

1. *Discharges for coloring matters.*—The materials used as discharges for vegetable coloring principles, are chlorine and chromic acid, the bleaching powers of which have before been alluded to.* To effect the topical discharge of a vegetable coloring matter by means of chlorine, with the production of a white figure, the dyed cloth is printed on those parts which are to be discharged, with a thickened acid mixture, the composition of which is varied according to the fastness of the color to be destroyed; and after being sus-

* See chapter I., Part II.

pended to dry for a day or two, the cloth is drawn (by a pair of squeezing rollers) through a solution of chloride of lime, not stronger than 8° Tw. or 1·040. The goods should be extended on rollers while being drawn through the solution, and should not occupy more than two or three minutes in their passage. As soon as the goods have passed through, they are put to soak in water; after which they are washed either by the dash-wheel or the rinsing machine, and then dried.

The chemical reactions which take place in this process, are by no means complicated. Chloride of lime does not of itself bleach Turkey-red and some other fast colors immediately; so that a cloth dyed with such colors may remain for some minutes in contact with a solution of chloride of lime without any deterioration in color. But the acid applied to certain parts of the cloth, combines with the base of the chloride and liberates free chlorine, which exerts an instantaneous bleaching action on the vegetable coloring matter on those parts of the cloth. Almost the only colors to which chlorine can be thus applied as a discharger, are Turkey-red and other madder colors and indigo, as the more delicate colors are easily discharged by chloride of lime alone.

A white discharger, adapted for all madder colors except Turkey-red, may be made *by dissolving 4 pounds of tartaric acid in a gallon of water, mixing this solution with a gallon of lime-juice, of spec. grav. 44° or 48° Twad., and thickening the mixture with pipe-clay and gum.*

The white discharger for Turkey-red, requires to be rather stronger than the above. It may be made *by mixing 4 pounds of tartaric acid with a gallon of lime-juice, at about 30° Twad. and after thickening with pipe-clay and gum, adding about a pound of concentrated sulphuric acid, or two pounds of bisulphate of potash.*

In a particular style of work, the Turkey-red is discharged by the direct topical application of chlorine, or rather of an aqueous solution of chlorine. It is in this way that the celebrated Bandana handkerchiefs, which have white figures on a dark ground, have been most successfully imitated by

Messrs. Monteith of Glasgow. The style is only practised in the manufacture of handkerchiefs. The process is as follows:—

From ten to fourteen pieces of cloth, previously dyed Turkey-red, are stretched over each other quite parallel, and passed together by portions at a time (proceeding from one end of the pieces to the other end), between two leaden plates, one of which is placed immediately over the other. Each of these leaden plates is cut completely through, so as to leave hollow places on all the parts required in white on the red ground. By means of a hydraulic press, the pieces of cloth are compressed between the leaden plates with a force of three hundred and twenty tons on the whole surface. While the cloth is exposed to this immense pressure, an aqueous solution of chlorine (obtained by adding sulphuric acid to a solution of chloride of lime), is made to percolate downward through the pieces by the openings in the leaden plates. As the compressed state of the cloth prevents the imbibition of the liquid except by the parts opposed to the design on the lead, the solution passes on in a circumscribed channel to the lower leaden plate, where it escapes and is conveyed away by a waste-pipe. The portions of cloth through which the liquid passes, are entirely deprived of their color. As soon as the chlorine solution is passed through, water is made to percolate in a similar manner to wash away the chlorine, else the definition of the pattern would be impaired. The passage through the cloth of the chlorine solution and the water for washing, is sometimes assisted by a pneumatic apparatus consisting of a large gasometer, from which a current of air is caused to proceed under a moderate pressure, and act in the direction of the liquid.

When a considerable quantity of water has passed through the cloths, the pressure is removed, and the pieces are washed and slightly bleached, whereby the lustre, both of the design and ground, is considerably increased. After the production of a white figure on a colored ground, by the application of the acid discharger and immersion in the solution of chloride of lime, colored figures may be applied, either to the ground or to the white figure, by grounding in topical colors by the hand-block. A common method of imparting a colored figure, is by mixing with the acid discharger one of the two solutions necessary for producing a mineral coloring material. For example, to impart a yellow figure to a piece of cotton dyed with Turkey-red, proceed as follows:—

1. Print by the machine with a chrome yellow discharger, composed of

1 gallon of lime-juice of spec. grav. 20° Twad.,
5 pounds of tartaric acid,
4 pounds of nitrate of lead, with a mixture of pipe-clay and gum as the thickener.

2. After hanging for a day or two, pass the piece through a solution of chloride of lime at 8° Twad.

3. Soak in water and slightly wince in water.

4. Wince for about a quarter of an hour, in a solution of bichromate of potash, containing from three to five pounds to the piece.

5. Pass through, or wince, in dilute muriatic acid, wash at the dash-wheel and dry.

To obtain both a white and a yellow figure on a Turkey-red ground, the dyed cloth may be printed with two acid dischargers, one intended for the production of the white, the other for the yellow figure. The subsequent treatment of the cloth is the same as above.

To impart a blue figure to the same ground, the dyed cloth is printed with a mixture of Prussian-blue, permuriate of tin, and tartaric acid, after which it is drawn through a solution of chloride of lime. The Turkey-red thereby becomes discharged, and the Prussian-blue fixed on all the parts where the mixture had been printed.

The only substance besides chlorine, which can be conveniently employed to effect the topical destruction or removal of vegetable coloring matters, is chromic acid, which produces the decomposition of the coloring matter, by virtue of its oxidizing power, the chromic acid becoming reduced to the state of green oxide of chromium. The vegetable coloring principle best adapted to this kind of work is indigo.

To obtain a white pattern on an indigo ground, by means of chromic acid, the cloth is first dyed uniformly with indigo, in the ordinary manner, and then padded with a solution of bichromate of potash, containing about five or six ounces per piece. After being carefully dried in the shade at the ordinary temperature, it is next printed with a discharger containing tartaric acid, oxalic acid, citric acid, and sometimes muriatic acid; and immediately after the impression, it is winced in water containing a little chalk in suspension, then washed by the dash-wheel, passed through dilute sulphuric acid, and lastly washed in clean water.

The color of the indigo on the cloth, is destroyed imme-

diately on the application of the acid discharger: chromic acid is then liberated from the bichromate, *through the superior affinity of the acids in the paste for the potash*, and the free chromic acid at once oxidizes and destroys the coloring matter. Indigo is almost the only substance which can be adapted to the chromic acid discharger, owing to the oxidizing action which the bichromate of itself exerts on vegetable coloring materials in general; *hence the reason also for drying the dyed goods, after being padded with the bichromate, in a darkened chamber and at the ordinary temperature.*

To produce a yellow instead of a white figure, the acid discharger may be mixed with a salt of lead; in other respects the process is the same as above.

The following method of obtaining a white figure on a dark green ground, is an example of the combination of the madder style of work, with the chromic acid discharge style:—

1. Dip the cloth in the blue-vat to the desired shade;
2. Pad in a mixture of red liquor, with bichromate of potash, containing five or six ounces of the latter to the gallon, and dry in the shade;
3. Print the cloth, without being washed, with a mixture of lime-juice, sulphuric acid, and oxalic acid;
4. Pass the cloth through a mixture of hot water and chalk, and dye in a decoction of quercitron bark;
5. Wash and clear by branning.

In this process, the mixture of lime-juice, sulphuric acid, and oxalic acid, not only liberates chromic acid from the bichromate of potash, but also dissolves the subsulphate of alumina deposited from the red liquor; the parts on which this mixture is applied, do not, therefore, become permanently dyed yellow when the cloth is exposed to the decoction of quercitron.

The discharge style is applicable to cloths dyed with mineral, as well as with vegetable and animal coloring matters.

1. A white figure may be produced on a ground of Prussian blue, by imprinting on the cloth a paste containing a caustic alkali (either potash or soda), and passing the cloth afterwards through a solution of oxalic acid. The Prussian

blue is here decomposed by the action of the alkali, affording yellow prussiate of potash, or prussiate of soda, which may be removed by washing, and peroxide of iron, which is precipitated on the cloth, but is afterwards dissolved out by the oxalic acid.

2. A white figure, on a ground of manganese brown, may be very readily obtained by imprinting the cloth, after being dyed brown in the ordinary manner, with a slightly acid solution of protochloride of tin, of a specific gravity about 70° or 80° Twad., or containing a pound and a half or two pounds of the protochloride per gallon, according to the intensity of the shade of the manganese ground. The solution of protochloride of tin is thickened with about a pound of starch to the gallon. The peroxide of manganese on the cloth is decomposed by the protochloride of tin, and converted into protochloride of manganese, which being a very soluble salt is easily dissolved out by washing, leaving the parts white, or nearly so, on which the salt of tin had been applied. Peroxide of tin is formed at the same time, and remains for the most part attached to the cloth, but being white, it does not vitiate the pattern.

To impart a design in white, blue, and yellow, on the bronze ground, the cloth on which the manganese has been raised, may be printed with the salts of tin for the white; with a mixture of berry liquor, alum, and salts of tin for the yellow; and with a mixture of salts of tin, prussiate of potash, pernitrate of iron, muriatic acid, and British gum, for the blue spots. The color of the latter mixture is at first greenish-white, but changes to blue on exposure to the air.

A design in different shades of red and pink, may be communicated to the same ground, by means of a mixture of peachwood or cochineal liquor with alum, perchloride, and protochloride of tin, thickened with gum tragacanth; and a mixture of logwood liquor, with alum and the two chlorides of tin, thickened with starch, may be used for imparting different shades of purple and violet to the same ground.

A figure in chrome-yellow, may be produced on a ground of manganese bronze, by printing on the dyed cloth a discharg-

ing material composed of tartaric acid, nitrate of lead, and salts of tin. After the cloth is dried, it is passed first through lime-water, then through a solution of bichromate of potash, and afterwards through dilute muriatic acid to brighten the yellow.

3. Protochloride of tin, when mixed with sulphuric, tartaric, or oxalic acid, is also used as the discharging material for chrome-yellow and chrome-orange. The discharge of the chromates of lead is effected, in this case, *by the reduction of the chromic acid to the state of green oxide of chromium, which forms soluble salts with the acids.*

A variety of colored designs may also be applied, by combining with the discharger, the materials for the production of a topical color. Thus, a blue figure is sometimes produced, by printing on the orange or yellow cloth, a mixture of the two chlorides of tin, Prussian blue, and muriatic acid; a violet figure, by logwood liquor mixed with alum, tartaric acid, protochloride of tin and starch; and a red or pink figure, by a similar mixture, containing peachwood liquor instead of logwood liquor.

4. A white figure on a ground of iron buff, is obtained, by applying to the colored cloth a mixture of tartaric and oxalic acids with lime-juice, thickened with pipe-clay, or China-clay and gum. The acids dissolve the peroxide of iron, and the figure is obtained perfectly white by washing. *The readiest way of discharging the iron, is to apply the acid mixture after the cloth has been padded in the iron liquor, and before it is exposed to the alkaline solution to precipitate the peroxide.* A solution of protochloride of tin in a dilute acid, thickened with starch, is also sometimes used as a white discharger for iron buff; and for producing colored designs, the protochloride may be mixed with perchloride of tin and either logwood, peachwood, or berry liquor.

The following method of producing white and buff-colored figures on a dark-green ground, is an example of the combination of such a process as the above with the resist style:—

1. The cloth is printed with the white resist for the indigo-vat;
2. It is dipped into the blue-vat, rinsed, and dried;

3. It is padded with rather weak iron liquor and aged;

4. A solution of tartaric and oxalic acids in lime-juice, thickened with pipe-clay and gum, is applied by the block to parts of the buff spots;

5. The cloth is washed in water holding chalk in suspension, to remove the acid paste;

6. Wince in an alkaline solution, to raise the buff, and then wash.

The white figure is here produced, by the discharge of the salt of iron from parts of the spots on which the indigo had been resisted; the buff figure is the remainder of those spots, and the dark green ground results from the mixture of the indigo with the buff.

Dischargers for Mordants.—Another method of producing white or colored figures on a colored ground, referable to the discharge style of work, is by the removal of the mordant previous to the application of the coloring material. This method is particularly adapted to grounds of madder and log-wood, with an iron or aluminous mordant. The material used for the discharge of the mordant, is usually a mixture of tartaric acid, oxalic acid, and lime-juice, the proportions of the constituents being varied according to the strength of the mordant to be discharged. The following mixture may be used for discharging the mordant from a piece of cloth impregnated with red liquor of spec. grav. 7° Twad. or weaker, or with iron liquor of spec. grav. 2° Twad., or weaker:—

1 gallon of lime-juice spec. grav. 6° Twad.,
3½ ounces of oxalic acid, and
4 ounces of tartaric acid,
Thickened with pipe-clay and gum if for application by the block, or with British gum if by the roller.

Sometimes the proportion of tartaric and oxalic acids, and the strength of the lime-juice, are considerably reduced, and bisulphate of potash, oil of vitriol, and cream of tartar, are introduced instead.

The ordinary operations practised on calico, in this style of work, to obtain a white figure, are the following:—

1. The cloth is padded or printed with the solution of the mordant for the ground, and is immediately dried by being drawn either through the hot-flue or over steam boxes;

2. After a moderate ageing, the calico, without being washed, is imprinted by

the roller with the discharging paste, which immediately dissolves the subsalt formed during the ageing;

3. The calico is next suspended for a day or two in a cool place, not very dry, and, if the mordant is peroxide of iron, it is then passed through water heated to about 130° F. and rendered slightly alkaline by the addition of a small quantity of carbonate of soda;*

4. The cloth is afterward washed, dunged, and dyed, in the vegetable infusion; after which it is cleared by soaping or branning and wincing in solution of chloride of lime, in the usual manner. Wherever the acid paste had been applied, the coloring material does not attach itself, in consequence of the removal of the mordant from those parts.

It will be observed that this kind of discharge work is very similar to the resist style, in which an acid paste is first imprinted on the cloth to prevent the attachment of a mordant subsequently applied to the whole surface of the cloth; the only difference between the two styles consisting in the order of applying the acid and the mordant. The best whites are no doubt generally procured by the resist style; as it is easier for an acid to prevent the attachment of a mordant in an insoluble form, than to dissolve it, when once precipitated.

To procure a white design on a black ground, by the discharge of the mordant, the cloth may be treated in the following manner:—

1. Pad or print the calico with a mixture of equal measures of iron liquor, of spec. grav. 6° Twad., and red liquor of 8° Twad., thickened with starch or British gum;
2. Dry over the steam boxes, age, and apply a discharger composed of tartaric acid, sulphuric acid, and lime-juice, thickened with British gum;
3. Pass the cloth through warm water mixed with chalk;
4. Dye in decoction of logwood, mixed with a little bran and dung;
5. Wash, clear the white by branning, rinse and dry.

The following method of producing white and blue figures on a purple or chocolate ground, presents an example of the combination of such a style as the above with the indigo resist style:—

1. The white calico is padded with red liquor;

* The passing of the cloth through a dilute solution of carbonate of soda is sometimes omitted, particularly when alumina is the mordant, in which case a quantity of chalk is added to the dung-bath to neutralize the free acid in the discharger.

2. After the cloth has been aged for a short time, the thickened acid discharger is applied by the cylinder to all the parts intended to be blue or white;

3. After hanging for twenty-four hours, the calico is dunged, dyed in the madder-bath, and cleared by branning;

4. On the parts of the white spots which are intended to remain white, the sulphate of zinc resist for the indigo vat, such as the mixture described at page 554, is imprinted;

5. After the cloth is dried, it is dipped in the blue-vat and exposed to the air; then washed at the dash-wheel, and dried.

The white figure is here produced through the discharge of the aluminous mordant by the acid, and by the action of the sulphate of zinc resist on the indigo: the blue figure is produced by the indigo on the white spots to which the resist was not applied, and the purple or chocolate ground results from the mixture of the indigo with the madder red.*

A discharger for one mordant is sometimes mixed with the solution of another mordant on which it exerts no action, so that the mordant in the discharger becomes attached to the cloth, on the spots from which the previous mordant is removed. Thus, subacetate of iron may be separated from a piece of calico, and alumina imparted in its place, by applying to the mordanted cloth a mixture of red liquor with protochloride of tin. In this manner, a red figure on a violet or lilac ground is sometimes produced, the cloth being first covered with weak iron liquor, then dried, printed with the mixture of red liquor and protochloride of tin, dunged, dyed in the madder bath, and cleared in the usual manner. To obtain a white figure as well as the red, the mordanted cloth should be also printed with lemon-juice, or with a mixture of lemon-juice and sulphuric acid.

V. THE CHINA BLUE STYLE.—The style of calico printing by which the china blue tints are produced, is an in-

* A simpler and better method of obtaining the same effect, is by the "chocolate ground neutral style." The cloth is first printed with the white cupreous resist (mixed with a free acid, when a very well defined figure is required), and afterwards with the chocolate resist for the ground, the parts required in blue being left white. The cloth is then aged, drawn once through the blue-vat, washed, dunged, dyed with madder, and cleared by branning. This interesting style of work is very little practised at present, it being superseded by the cheaper but much less permanent steam blue and steam sapan chocolate.

teresting modification of the topical style. These prints are distinguished by having blue figures, usually of two or three different depths of color, associated with white.

To produce such a pattern, the bleached calico is subjected to the following operations:—

It is first printed, either by the block or cylinder, with a mixture of indigo, orpiment (sulphuret of arsenic), sulphate of iron or iron liquor, gum or starch, and water; the proportions of gum or starch and water being varied according to the depth of color required. After being printed, the calico is suspended in a dry atmosphere for a day or two, and stretched in perpendicular folds on a rectangular wooden frame, suspended by pulleys and a rope from the ceiling of the apartment. The frame with the cloth is then dipped in a certain order into the three following liquids: No. 1, milk of lime;* No. 2, solution of copperas; No. 3, solution of caustic soda. These liquids are contained in three adjacent stone cisterns, the tops of which are on a level with the ground: the usual dimensions of the cisterns are eight or nine feet in length, four feet in depth, and three feet in width.

The goods are dipped several times, alternately, in the vats No. 1 and No. 2, with exposure to the air for a short time between each dip; they are not dipped so frequently into the vat No. 3, and the dipping in this always immediately follows No. 2. By these operations, the insoluble indigo-blue applied to the surface of the cloth becomes converted into indigotin, which is dissolved and transferred to the interior of the fibres, where it is precipitated in the original insoluble form.

The various phenomena which occur in the dipping of China blues, are not difficult of explanation with the lights of modern chemistry.†

The following method of preparing the China blue mixture of different shades is described by M. Thillaye, in his useful work on calico-printing.‡ The materials employed are,

15¾ pounds of indigo, in coarse powder,
3¾ pounds of orpiment,
22 pounds of copperas, and
9½ gallons of water, or water and gum-water.

The indigo, orpiment, copperas, and four gallons and a half of the water, are well ground together in a mill for three days; the mass is then removed, and the mill is washed with

* The milk of lime, for dipping China blue prints, may be prepared by mixing two hundred pounds of lime with a thousand gallons of water. When in constant use, the lime-vat requires to be replenished twice daily, both with lime and water.

† See chapter V., Part III.

‡ Manuel du fabricant d'Indiennes, Paris, 1834.

a gallon of water which is added to the mixture. The remaining four gallons of water are afterwards added; but if a very thick blue is required, as much strong gum-water is introduced instead. From this mixture, which may be called No. 1, several lighter shades are procured by diluting it with water or gum-water in the following order:—

No.	Quantity by measure of No. 1.		Quantity by measure of water or gum-water.
1	1	mixed with	0
2	11	"	1
3	10	"	2
4	8	"	4
5	6	"	6
6	4	"	8
7	2	"	10
8	2	"	12
9	2	"	14
10	2	"	16
11	2	"	18
12	2	"	20

To produce a small single blue figure, the mixture No. 5, thickened with starch, may be applied by the block, and No. 4, thickened with gum, by the roller.

For two different blues, applied by the block, there may be used, 1st, the mixture No. 4, thickened with starch; and 2nd, No. 9, thickened with gum.

For three different blues, applied by the block, there may be taken, 1st, the mixture No. 5, thickened with starch; 2nd, No. 7, thickened with starch; and 3rd, No. 10, thickened with gum.

The mixture described by M. Thillaye is not exactly the same as that commonly employed in England. Instead of copperas, the Lancashire printers generally use iron liquor, and British gum instead of common gum; they also take little more than half as much orpiment as is directed in the recipe of M. Thillaye. The following proportions of the materials will probably be found to form a convenient mixture:—

16 pounds of indigo,
5 or 6 gallons of strong iron liquor,

2 pounds of orpiment, and
British gum and water sufficient to make 8 gallons.

When required for use, this mixture, which contains two pounds of indigo to the gallon, may be diluted with water or gum-water in the following order :—

No.	Quantity by measure of above mixture.	Quantity by measure of water or gum-water.	Quantity of indigo in one gallon of the mixture. lbs.	oz.
1	1	0	2	0
2	1	½	1	5¼
3	1	¾	1	3¼
4	1	1	1	0
5	1	2	0	10¾
6	1	3	0	8
7	1	5	0	5¼
8	1	7	0	4
9	1	9	0	3¼
10	1	12	0	2¼
11	1	16	0	1¼

The strength of the solution of copperas is varied from 3½° Twad. (1·017) to 6° Twad. (1·030), it being regulated more by the quantity of the figure in the pattern than by the depth of color required. The kind of copperas generally preferred for this purpose is that technically known as "green copperas."*

The copperas vat does not require replenishing quite so frequently as the lime-vat, and the cistern need not be emptied for six months or longer. The bottom and sides of the cistern become lined with a dense crystalline deposit of oxide of iron and sulphate of lime, as hard as the cistern itself. The strength of the solution of caustic soda may vary from 6° to 9° Twad. (1·030 to 1.045). It is made in the usual manner *by carbonate of soda and quick-lime.*

The order of dipping the frame into the three cisterns is as follows :—

1. Dip in the first vat (lime) for ten minutes; drain for five minutes.
2. Dip in the second vat (copperas) for ten minutes; drain for five minutes.
3. Dip in the first vat for ten minutes; drain for five minutes.
4. Dip in the second vat for ten minutes; drain for five minutes.

* See chapter V., Part III., articles *Chemistry of the Blue Vat*, *Sulphate of Iron*, *Impurity of Copperas*, and *the Common Blue Vat.*

5. Dip in the third vat (soda) for ten minutes; drain for five minutes.
6. Dip in the second vat for ten minutes; drain for five minutes.
7. Dip in the first vat for ten minutes; drain for five minutes.
8. Dip in the second vat for ten minutes; drain for five minutes.
9. Dip in the first vat for ten minutes; drain for five minutes.
10. Dip in the second vat for ten minutes; drain for five minutes.
11. Dip in the third vat for ten minutes; drain for five minutes.*

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* Dr. Ure's remarks on this style (the China-blue style) are as follows:—

Take 16 pounds of coarsely ground indigo, and

4 pounds of sulphuret of arsenic; dissolve 22 pounds of sulphate of iron in 6 gallons of water; introduce these three matters into the indigo mill, and grind them for three days. If it be wished to have a thickened blue, this mixture must have pounded gum added to it; but if not, 5 gallons of water are added. This color may be called blue No 1.

The following table exhibits the different gradations of China blue:—

Course.	Quantity by measure of No. 1.	Quantity by measure of water or mucilage.
No. 1	1	0
2	11	1
3	10	2
4	8	4
5	6	6
6	4	8
7	2	10
8	2	12
9	2	14
10	2	16
11	2	18
12	2	20

I shall now give examples of working this style by the block and cylinder:—

Impression of a single blue with small dots.

For the block, blue No. 5, thickened with starch.

For the cylinder, No. 4, thickened with gum.

Impression of two different blues with the block.

First blue, No. 4, with starch.

Second blue, No. 9, with gum.

Impression of three blues with the block.

First blue, No. 5, with starch.

Second blue, No. 7, with starch.

Third blue, No. 10, with gum.

After printing-on the blues, the pieces are hung up for two days, in a dry and airy place, but not too dry; then they are dipped as follows:—Three vats are mounted, which may be distinguished by the numbers 1, 2, 3.

No. 1. 300 pounds of lime to 1,800 gallons of water.

No. 2. Solution of sulphate of iron of spec. grav. 1·048.

3. Solution of caustic soda of spec. grav. 1·055; made from soda crystals, quicklime, and water, as usual.

In the dipping of China blues, care should be taken to swing the frames during the operation; and when the last dip is given, the piece is to be plunged upon its frame into a fourth vat, containing dilute sulphuric acid of spec. grav. 1·027. This immersion is for the purpose of removing the oxide of iron, deposited upon the calico in the alternate passages through the sulphate of iron and lime vats. They are then rinsed an hour in running water, and finally brightened in the above dilute sulphuric acid, slightly tepid. Sometimes they are subjected to a soap bath, at the temperature of 120°. By the addition of nitrate of lead to the indigo vat, the blue becomes more lively.

VI. *Steam colors.*—Before the printed cloth is exposed to steam, the coloring matter may in general be easily removed by washing with pure water; but afterwards it is attached to the tissues almost as strongly as in any other style of printing, presenting, moreover, a brilliancy and delicacy hardly attainable by any other process.* Printing by steam is one of the most important of modern improvements in calico-printing; it is practised not only on goods of cotton, but also on silk, woolen cloths, and chalys.

The brilliancy and permanency of almost all steam colors are greatly increased by impregnating the cloth with a solution of tin, or, for some styles, with a solution of acetate of alumina, previous to the application of the colors. The solution of tin now commonly used for this purpose is the *stannate of potash*, which is, when properly made, a solution of peroxide of tin in caustic potash; this preparation sometimes contains protoxide of tin, but the stannate containing the peroxide only is preferred.† This alkaline solution is not so injurious to the fibre of cotton as the perchloride. After having been padded in the solution of stannate of potash, the pieces are usually

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The pieces being suspended on the frames, are to be dipped in the first vat, and left in it ten minutes; then withdrawn, drained for five minutes; next plunged into the second vat for ten minutes, and drained also for five, &c.

* All the fugitive topical colors not fixed by steaming are termed *spirit, fancy*, or *wash-off colors*.

† See page 270.

passed through a cistern containing a solution of muriate of ammonia, to produce a precipitate of peroxide of tin. Some printers employ very dilute sulphuric acid instead of a solution of muriate of ammonia, but the latter is decidedly preferable.

To the cloth thus prepared, or occasionally without any preparation except bleaching, the solutions of the mixed coloring materials and mordants, properly thickened, are applied either by the roller or block. Steam colors are chiefly grounded in by the block to cloths which have been already printed and finished off according to other styles of work, particularly the madder style.

The following recipes will afford examples of the principal mixtures which are applied to cotton as steam colors. The mordant most frequently used for steam colors is red liquor, mixed with oxalic or some other acid to prevent the precipitation of the compound of coloring matter and mordant.

Steam red.—The best steam red for cotton is obtained by decoction of cochineal, with oxalic acid and protochloride of tin. The mixture obtained according to the following recipe may be applied either by the roller or block:—

1 gallon of cochineal liquor of 6° Tw.,
1 pound of starch,
3 ounces of oxalic acid,
4 ounces of cryst. protochloride of tin.

The cochineal liquor is first boiled with the starch for a few minutes; when the mixture is half cold, the oxalic acid is added, and as soon as the acid is dissolved the salt of tin is introduced.

A cheaper but less brilliant steam red, extensively used by some printers, is prepared by substituting peach-wood liquor for cochineal liquor in the above.

Steam pink.—A decoction of Brazil-wood with a small quantity of the solution of muriate of tin, called, at Manchester, *new tin crystals*, and a little nitrate of copper to assist in fixing the color; properly thickened, dried, and steamed for not more than twenty minutes, on account of the corrosive action of muriate of tin when the heat is too strong.

Cochineal pink.—Acetate of alumina is mixed with decoction of cochineal, a little tartaric acid and solution of tin; then thickened with starch, dried, and steamed.

Steam yellow.—Either decoction of Persian berries, decoction of quercitron, or decoction of fustic, may be used as a steam yellow, but the first is most commonly employed.

No. 1.

1 gallon of berry liquor of 4° Tw.,
5 ounces of alum, thickened with about
14 ounces of starch.

No. 2.

1 gallon of berry liquor of 4° Tw.,
1½ gill of red liquor of 18° Tw.,
2 ounces of crystals of protochloride of tin, and about
14 ounces of starch.

The mixture made according to the following recipe, affords a darker shade than either of the preceding :—

No. 3.

1 gallon of a mixture of equal measures of decoction of Persian berries at 15° Tw., and of decoction of fustic at 15° Tw.,
14 ounces of starch,
7 ounces of alum,
7 ounces of crystals of protochloride of tin.

The decoctions of the dye stuffs are mixed with the alum and starch, and heated until properly thickened; the mixture should be soon withdrawn from the fire, and when cold mixed with the salt of tin.

The preparation made as No. 2 will probably be found superior to either of the others for cotton goods. The steaming for No. 3 must be continued only a short time, else the fibre of the cotton would be apt to become corroded by the salt of tin. This preparation is better adapted (as a steam color) for fabrics of wool and silk than for those of cotton, but it may be advantageously applied to cotton as a spirit or wash-off color. An orange stripe may also be produced by a decoction of Persian berries, the mordant being protoxide of tin only. A convenient mixture for producing this color is made as follows :—

1 gallon of berry liquor made from three pounds of berries to the gallon, and

4 ounces of cryst. protochloride of tin. Boil together for a few minutes and thicken with

3 to 4 pounds of British gum, or 1 pound of starch.

The cloth may be steamed and washed in the usual manner, but this color becomes strongly attached by merely ageing the cloth for two or three days, and then passing it through hot chalky water.

Steam blue.—A very beautiful steam blue may be communicated to cotton and *woolen* goods by means of a mixture of yellow or red prussiate of potash, with tartaric, oxalic, or sulphuric acid, and alum or perchloride of tin. If for applying to cotton goods, alum is used; but if for woolen fabrics, perchloride of tin is preferable. For printing on cottons by the roller, either No. 1 or No. 2 of the following mixtures may be used:—

No. 1.

1 gallon of water,
1¼ pounds of yellow prussiate of potash,
3 to 4 ounces of alum,
5 to 6 ounces of oil of vitriol,
1½ pounds of starch.

No. 2.

1 gallon of water,
1¼ pounds of yellow prussiate of potash,
3 to 4 ounces of alum,
10 to 12 ounces of tartaric acid,
1½ pounds of starch.

The starch and prussiate of potash are boiled in the water, and when the mixture is withdrawn from the fire and cooled, the sulphuric or tartaric acid and alum are introduced. The mixture made as No. 2 affords a more lively color than that made as No. 1, but the latter is least expensive.

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* *Steam blue.*—Prussiate of potash, tartaric acid, and a little sulphuric acid, are dissolved in water, and thickened with starch; then applied by the cylinder, dried at a moderate heat, and steamed for 25 minutes. They are rinsed and dried after the steaming. The tartaric acid, at a high temperature, decomposes here a portion of the ferrocyanic acid, and fixes the remaining ferrocyanate of iron (Prussian blue) in the fibre of the cloth. The ground may have been previously padded and dyed; the acids will remove the mordant from the points to which the above paste has been applied, and bring out a bright blue upon them.—*Ure.*

No. 3.

1 gallon of water,
3 to 3½ ounces of alum,
1½ to 2 ounces of oxalic acid,
3 to 4 ounces of tartaric acid,
20 ounces of gum,
12 ounces of yellow prussiate of potash.

The gum, acids, and alum, may be first dissolved in the water with the assistance of heat, and when the mixture is quite cold, the prussiate of potash is added. The time necessary for steaming cottons printed with either of these preparations *is about thirty minutes.* When withdrawn from the steaming cylinder or chamber, the goods present, if *yellow* prussiate of potash is used, a blueish-white color, which changes to deep blue on exposure to the air for a couple of days. The chemical change by which the color is produced during the exposure to air depends on the absorption of oxygen or the removal of hydrogen; as is evident from the circumstance, that if the goods are passed through a solution of bichromate of potash as soon as withdrawn from the steaming cylinder or chamber, the blueish-white changes to deep blue immediately. If the *red* prussiate of potash is employed instead of the yellow prussiate, the cloths acquire the proper blue color during the steaming, and the depth of the color is not sensibly increased by exposure to air or to a solution of bichromate of potash.*

Orange.—(See Steam Green.)

Steam Green.—A very good steam green may be communicated to cotton goods by combining the materials for producing a yellow, with the preceding mixture for steam blue; thus,

1 gallon of berry liquor made from a pound and a half of Persian berries (or of 4° Tw.)
12 ounces of yellow prussiate of potash,
3 to 4 ounces of crystals of protochloride of tin,
5 to 6 ounces of alum,
3 to 4 ounces of oxalic acid.
Thicken with gum.

* See chapter V., Part III., and chapters IV. and VI., of the same Part.

The oxalic acid, the muriatic acid derived from the salt of tin, and the sulphuric acid united with alumina in the alum, should form, together, one equivalent, or a quantity sufficient for the saturation of one equivalent of a protoxide for every two thirds of an equivalent of the prussiate. The time required for steaming this color *is about thirty minutes.*

After the color mixtures are printed on, the calico is dried in a warm atmosphere for two days before being exposed to the action of the steam. The most common method *of applying the steam* is the following :—

Three or four pieces of the printed and dried calico are stitched together at the ends and coiled round a hollow cylinder of copper, about three feet in length and four inches in diameter, and perforated with holes about one-twefth of an inch in diameter and half an inch distant from each other. One of the ends of the cylinder is open, to admit the steam; the other is closed. The calico is prevented from coming immediately into contact with the cylinder by a roll of blanket stuff, and is covered with a piece of white calico tightly tied around the roll. During the lapping and unlapping of the goods, the column is placed horizontally in a frame, in which it is made to revolve; but during the steaming it is fixed upright, and supplied with steam through its bottom from the main steam boiler of the works, the quantity admitted being regulated by a stop-cock. During the whole process the temperature of the steam should be as near 211° or 212°, as possible: *the condensation which takes place below that degree is apt to cause the colors to run;* but a higher temperature is also injurious, as a slight condensation, sufficient to keep the goods always moist, is essential to the success of the process.

The steaming is continued for from twenty minutes to three quarters of an hour, according to the nature of the fabric and the coloring mixture. The usual time with cottons is *twenty-five minutes,* and with de laines from *thirty to thirty-five minutes.* When the steam is cut off the goods should be immediately unrolled to prevent any condensation: they are then soft and flaccid, the material used as a thickener for the colors being in a semi-fluid state; but on exposure to the air for a few seconds only, the thickener solidifies, and the goods become perfectly dry and stiff. After the pieces have been aged for a day or two, the thickener is separated by a gentle wash in cold water.

To produce with steam colors a pattern only containing a design in *lilac, pink, red, yellow, black,* and *dark orange red,* the

cloth may be printed by the five-color machine, in the following order :—

1. By the first roller, with a mixture of logwood liquor, starch, and solution of tin for producing the lilac;
2. By the second and third rollers, with the mixtures for the pink and red, one containing weaker cochineal or peachwood liquor than the other;
3. By the fourth roller, with the mixture for the yellow;
4. By the fifth roller, with the mixture for steam black;

The dark orange red results from the mixture of the red with the yellow. After being steamed, the cloth is aged in a warm room for two days and two nights, and then washed at the rinsing machine.

The following style, for producing a design in black, red, brown, green, and yellow on a white ground, is a combination of the madder style with a topical brown and steam colors, which is susceptible of a great variety of interesting modifications :—

1. The cloth is printed by the three-color machine in the following manner: with iron liquor, for black, by the first roller; with red liquor by the second roller, and with catechue brown, by the third roller.
2. After being printed, the cloth is aged for two days, dunged, dyed in the madder-bath and cleared.
3. The cloth is lastly printed by the block with the mixtures for steam green, and steam yellow, then steamed, aged, and washed.

By a similar series of operations, a design may be imparted in black, brown, lilac, pink, green, blue, orange, and yellow, on a white ground. The cloth is first printed by the four-color machine with iron liquor of two strengths, one for the black, the other for the lilac; with red liquor for the pink, and with the mixture for catechue brown. After being aged, dunged, dyed with madder, and cleared as usual, the cloth is printed by the block with the mixtures for steam blue and steam yellow, and then steamed in the ordinary manner. To produce the orange, the steam yellow is printed on a part of the pink, and the green results from a mixture of some of the yellow with the blue.

As an example of the combination of madder colors with steam colors, for red and chocolate stripes, the cloth may be

printed with red liquor and the mixture of red liquor with iron liquor, and after dunging, dyeing, and clearing in the usual manner, the mixture for steam orange may be applied by the block.*

Steam Purple.—This topical color is made by digesting acetate of alumina upon ground logwood with heat; straining, thickening with gum senegal, and applying the paste by the cylinder machine. To a gallon of red liquor of 18° Tw., heated to about 140° Fahr., three pounds of ground logwood are added; the mixture is well stirred for about half an hour, and then strained through a cloth filter, the residue on the filter being washed with two quarts of hot water, which are received into the first liquid. The mixture thus obtained may be diluted with water, according to the shade of color required; for a moderate depth, one measure may be mixed with three of water, and thickened with starch, flour, or gum. This preparation may be applied either by block or roller.†

Steam Black.‡—The first of the mixtures following is best adapted for the roller, the other for grounding in by the block:—

No. 1.

1 pint of red liquor of 18° Tw.,
2 pints of iron liquor of 24° Tw.,
1 gallon of logwood liquor of 8° Tw.,
1¼ pounds of starch,
1½ pints of pyroligneous acid of 7° Tw.

All these materials may be mixed promiscuously and then boiled for a few minutes to form a mucilage. The cotton requires to be steamed about thirty minutes.

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* *Green, blue, chocolate, with white ground, by steam.*—Prussiate of potash and tartaric acid, thickened, for the blue; the same mixture with berry-liquor and acetate of alumina, thickened, for the green; extract of logwood with acetate of alumina and cream of tartar, thickened, for the chocolate. These three topical colors are applied at once by the three-color cylinder machine; dried and steamed. Though greens are fixed by the steam, their color is much improved by passing the cloth through solution of bichromate of potash.—*Ure.*

† See chapter I., Part III., article *Mercer's Assistant Mordant.*

‡ *Steam Brown.*—A mixed infusion of logwood, cochineal, and Persian berries, with cream of tartar, alum (or acetate of alumina), and a little tartaric acid, thickened, dried, and steamed.

No. 2.

3½ pints of peachwood liquor of 6° Tw.,
7 pints of logwood liquor of 6° Tw.,
12 ounces of starch,
14 ounces of British gum,
3 ounces of sulphate of copper,
1 ounce of copperas,
3 ounces of a neutral solution of pernitrate of iron, made by mixing one pound of acetate of lead with three pounds of the common acid nitrate of iron of 122° Tw.

The logwood liquor and peachwood liquor are mixed and divided into two equal portions, one of which is boiled for a short time with the starch, and the other with the British gum. The two liquids are afterwards mixed, and the remaining ingredients are added; the nitrate of iron being introduced last, but not before the mixture is cold.

PRINTING OF SILKS, MERINOES, MOUSSELIN DE LAINES, &c.—The fixation of coloring matters on fabrics of silk and wool is commonly effected by the process of steaming. These fabrics were formerly printed entirely by the block, but latterly the roller and the press-machine have been substituted.

The color mixtures for de laines, which are formed of cotton and wool, should be of such a nature as to afford a uniform deposite of coloring matter on both the animal and vegetable fibre. These mixtures are sometimes composed of two distinct bases, one capable of attaching itself firmly to the wool, the other to the cotton. Thus, a preparation sometimes used for imparting a blue color to the laines, is a mixture of the steam blue for cotton, with indigo-paste or soluble blue (sulph-indigotate of potash) for the wool. In a peculiar kind of fancy dyeing, the woolen thread only is dyed, and the cotton is afterward perfectly bleached *by exposing the dyed de laines to a dilute solution of bleaching powder.*

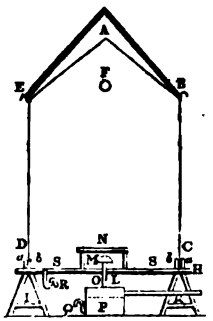
In general, the only difference between the composition of the mixtures for steam colors for woolen goods and those for cotton goods, is that the former contain more free acid than the latter, or that the coloring matter is held in solution more strongly in the former than in the latter. Whether the mordant is perchloride of tin, protochloride of tin, or alum, a con-

siderable quantity of tartaric or oxalic acid, is almost always introduced. The most vivid colors are generally obtained by protochloride of tin with either oxalic or tartaric acid.*

All the prints above referred to are applied, not by the cylinder but the block, and are fixed by the application of steam in one of four ways; 1. By the *lantern;* 2. By the *cask;* 3. By the *chest;* or, 4. By the *chamber.*

1. *By the lantern.*—In this mode of exposure to steam, the goods are stretched upon a frame; and therefore the apparatus may be described under two heads; the lantern and the frame. The former is made of copper, in the shape of a box A B C D E, fig. 34, open below, and with a sloping roof above, to facilitate the trickling down of the water condensed upon the walls. The sides B C D E, are 4½ feet high, 6 feet long, and 4 feet wide. The distance of the point A, from the line E B, is 2 feet. At F, is a brass socket, which may be stopped with a cork; and there is a similar one at the other side. This kind of penthouse may be raised by means of a pulley with cords fixed to the four angles of the roof E B; and it rests upon the table G H, a little larger than the area of the box, which stands upon the four feet I K. Round the borders of the table there is a triangular groove *a b*, for receiving the lower edges of the box, and it is stuffed steam-tight with lists of cloth. Through the centre of the table, the two-inch steam pipe M, passes; it is surmounted with a hemispherical rose pierced with numerous holes for the equal distribution of the steam. Right above it, a disc N, is placed upon four feet. The tube L, communicates

Fig. 34.



* The brilliant steam-blue distinguished when on woolen goods as "royal blue," is formed through the decomposition of hydroferrocyanic acid. The composition of the mixture printed on the cloth is much the same as the steam-blue for cotton, but is more concentrated, and perchloride of tin is introduced instead of alum. The solution of yellow prussiate of potash, which should contain not less than three pounds of the prussiate in a gallon, is mixed with sufficient tartaric acid to precipitate the whole of its potash as bitartrate of potash (cream of tartar), which may be separated and employed in the preparation of tartaric acid.

with a box P, which has a syphon Q, to let off the condensed water. At the upper part of this box the tube L, terminates. The table G H, slopes towards the part G, where the syphon R is placed for drawing off the water.

The *frame* is of such dimensions, that it may stand in the four corners of the table at S S. The second part embraces an open square frame, which is formed by spars of wood 2 inches square, mortised together; and is 3 feet 8 inches wide, 5 feet 8 inches long, and 4 feet 3 inches high; it is strengthened with cross bars. Upon the two sides of its breadth, two rows of round brass hooks are placed, about half an inch apart; they are soldered to a copper plate fixed to uprights by means of screws.

Before hanging up the goods, a piece of cloth 3 feet 8 inches long, and 4 feet wide, is placed upon the row of hooks; and 3 feet of it are left hanging out.

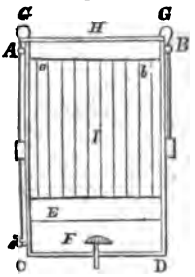
One foot within, the hooks pass through the cloth. A similar one is fitted to the other side. This cloth is intended to cover the goods hung upon the hooks; and it is kept straight by resting upon strings. The pieces are attached zig-zag from one hook to another. When the frame is filled, the bag is put within the cloths; it has the same rectangular shape as the frame. The pieces are in this way all incased in the cloth; a bit of it being also put beneath to prevent moisture affecting that part.

When shawls are framed they are attached with pins; and if they be too large, they are doubled back to back, with the fringes at top.

These arrangements being made, the frame is set upon the table, the penthouse is placed over it, and the steam is admitted (say) from 35 to 45 minutes, according to circumstances. The orifice F, is opened at first to let the air escape, and when it begins to discharge steam it is stopped. The frame is taken out at the proper time, the bag is removed, the cloths are lifted off, and the goods are spread out for airing. Three frames and six bags are required for a constant succession of work. The above apparatus is particularly suitable for silks.

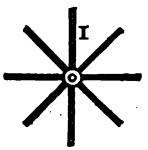
2. *The drum.*—This is the most simple mode of steaming.

Fig. 35.



The apparatus is a drum of white wood, 2 inches thick, Fig. 35; the bottom is pierced with a hole which admits the steam-pipe F, terminating in a perforated rose. Four inches from the bottom there is a canvass partition E, intended to stop any drops of water projected from the tube F, and also to separate the condensed water from the body of the apparatus. The drum is covered in by a wooden head H, under which the goods are placed. It is made fast either by bolts or by hooks, G, G, thus, ꝏ, to which weighted cords are hung. The frame, I, Fig. 36, rests upon the hoop a few inches from the edge. The goods are hung upon the frame in the ordinary way, and then wrapped round with flannel. The frame is studded with pin points, like that of the indigo vat, fixed about 5 inches asunder. From 20 to 30 minutes suffice for one steaming operation. The upper part of the frame must be covered also with flannels to prevent the deposition of moisture upon it. At the bottom of the drum there is a stop-cock to let off the condensed water. According to the size of the figure, which is 3 feet 2 inches, 50 yards may be hung up single; but they may be doubled as occasion may require.

Fig. 36.



3. *The box.*—This steaming apparatus is convenient from the large quantity of goods admissible at a time: it answers best for woolen goods. From 12 to 16 pieces, of 36 yards each, may be operated upon at once; and from 240 to 260 shawls. It is formed of a deal box, A, B, C, D, Fig. 37, 4 feet wide, 6 long, and 3 high; the wood being 4 inches thick. It is closed by a cover of the same substance, I, which is made steam-tight at the edges by a list of felt. The lid is fastened down by 5 cross bars of iron, *a*, *a*, *a*, *a*, *a*, which are secured by screws, *c*, *c*, *c*, *c*, *c*, Fig. 38. The ends of these cross bars are

Fig. 37.

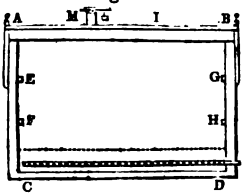
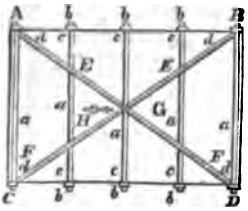


Fig. 38.



let into the notches *b*, *b*, *b*, *b*, *b*, on the edge of the box. The safety valve M, fig. 37, is placed upon the lid. For taking off the lid, there are rings at the four corners, *d*, *d*, *d*, *d*, bearing cords, F, F, F, F. These join at the centre into one, which passes over a pulley. Eight inches from the bottom of the box there is a horizontal canvass partition, beneath which the steam is discharged from the pipe L, fig. 39. There are two ledges, E, F, G, H, at the sides for receiving the bobbins. The tube, E, runs round the box, as shown by the letters *d*, *a*, *e*, *b*: the end, *d*, is shut; but the side and top are perforated with many holes in the direction towards the centre of the box. Fig. 40 shows the arrangement of the lower set of bobbins; that of the upper set is shown by the dotted lines: it is seen to be in an alternate position, one lying between two others. They are formed of pieces of deal 4 inches broad, 1 inch thick, and of a length equal to the width of the box. They are first wrapped round with 5 or 6 turns of doubled flannel or calico: the piece of goods is laid over it upon a table, and then wrapped round. At the end of the piece, several folds of the covering must be put, as also a roll of flannel. The two ends must be slightly tied with packthread. When these flat bobbins are arranged in a box, the steam is let on them, and continued about 45 minutes; it is then shut off, the lid is removed and the pieces are unrolled.

Fig. 39.

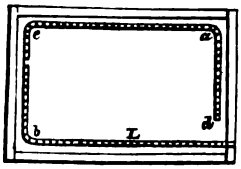
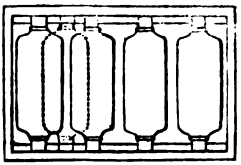
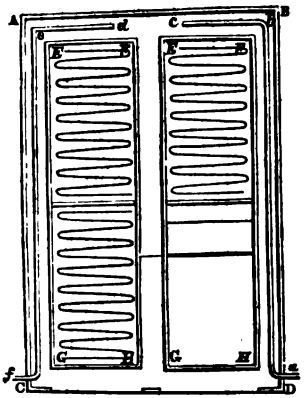


Fig. 40.



4. *The chamber.*—The interior height of the chamber, A, B, C, D, fig. 41, is nine feet, the length 12 feet, and the breadth 9 feet. The steam is introduced into it by two pipes, *a b c*, *d e f*. Their two ends, *d*, *c*, are shut; but their sides are all along perforated with small holes. The frames, E, F, G, H, are moveable, and run upon rollers: they are taken

Fig. 41.



out by front doors, which are made of strong planks, shut by sliding in slots, and are secured by strong iron bars and pressure screws. The cross rods, E, F, G, H, are provided with hooks for hanging up the pieces. There is a safety-valve in the top of this large chamber. The dimensions of the frame are 10 feet long, 3 feet wide, and 7 high. Three feet and a half from the upper part of the frame, a row of hooks is fixed for hanging on a double row of pieces, as shown in the figure. Over the frame, woolen blankets are laid to protect it from drops of water that might fall from the roof of the chamber. When the hooks are two-thirds of an inch apart, 24 pieces, of 28 yards each, may be suspended at once. The period of steaming is from 45 to 60 minutes.

Muslins and silks do not require so high a temperature as woolen goods. When the stuffs are padded with color, like merinoes and chalys, they must not be folded together, for fear of stains, which are sometimes occasioned by the column in steam calico-printing, where the end which receives the first impression of the steam is seldom of the same shade as the rest of the goods. The duration of the steaming depends upon the quantity of acid in the mordant, and of saline solution in the topical color; the more of which are present the shorter should be the steaming period. A dry vapor is requisite in all cases; for when it becomes moist, from a feeble supply or external condensation, the goods become streaky or stained by the spreading of the colors.

1. *Black figures* are given by decoction of logwood thickened with starch, to which a little oxalic acid is added while hot, and, after it is cold, neutralized solution of nitrate of iron.

2. *Dark blue for a ground.*—Decoction of logwood, and archil thickened with starch; to which, while the paste is hot,

a little soluble Prussian blue is added; and, when it is cold, neutralized nitrate of iron.

3. *Deep poppy or ponceau color.*—Cochineal boiled in starch water, with oxalic acid (or tartaric), and perchloride of tin.

4. *Rose.*—Cochineal infusion; oxalic acid; perchloride of tin; thickened with gum.

5. *Dark amaranth.*—Decoctions of archil and cochineal, thickened with starch: to the paste, alum and perchloride of tin are added.

6. *Capuchin color.*—Quercitron and cochineal thickened with starch; to the paste add oxalic acid and perchloride of tin.

7. *Annotto orange.*—Dissolve the annotto in soda ley, of spec. grav. 1·07, at a boiling heat; add aluminate of soda, and thicken with gum.

8. *Golden yellow.*—Decoction of Persian berries thickened with starch; to which some alum and muriate of tin are added, with a little perchloride of tin and oxalic acid.

9. *Lemon yellow.*—Persian berries; starch; alum.

10. An ammoniacal solution of cochineal is used for making many violet and mallow colors. It is prepared by infusing cochineal in water of ammonia for 24 hours; then diluting with water, heating to ebullition, and straining.

11. *Fine violet* is given by ammoniacal cochineal, with alum and oxalic acid; to which a little aceto-sulphate of indigo is added, and gum for thickening. The following blue may be used instead of the solution of indigo. The *mallow* tint is given by adding a little perchloride of tin to the above formula, and leaving out the blue.

12. *Dark blue.*—Soluble Prussian blue; tartaric acid; alum, thicken with gum.

13. *Emerald green.*—One quart of decoction, equivalent to 1 pound of Persian berries; 1 quart of infusion of quercitron, of spec. grav. 1·027; in which dissolve 12 ounces of alum in powder; and add 6 ounces of the following blue bath for greens; thicken with 20 ounces of gum.

14. Blue bath for greens. Half a gallon of water at 140°

F., one pound of soluble Prussian blue, 3 ounces of tartaric acid, and 2 ounces of alum.

I. *Printing of Silks.—Of the madder style.* This is one of the most difficult to execute, requiring much skill and experience. The first step is the removal of the gum. A copper being nearly filled with water, the pieces, tied up in a linen bag, are put into it, with a quarter of a pound of soap for every pound of silk, and are boiled for 3 hours. If the silk be Indian, half an ounce of soda crystals must be added. When the goods are taken out, they are rinsed in the river, then passed through water at 140° F., holding 8 ounces of crystalized soda in solution, as a scourer. They are next rinsed in cold water, and steeped in water very faintly acidulated with sulphuric acid, during 4 hours, then rinsed, and dried.

Preparation of Mordants.—1 gallon of boiling water; 2 pounds of alum; dissolve:

1 pound of acetate of lead; 4 ounces of sal ammoniac; 1 of chalk; mix well together; after decomposition and subsidence, draw off the clear.

1. *Red.*—1 gallon of the above mordant, thickened with 14 ounces of starch, and tinged with decoction of Brazil-wood. If dark red be wanted, dissolve, in a gallon of the above red, 4 ounces of sulphate of copper.

2. *Black.*—1 gallon of iron liquor, of 1·056 spec. grav.; thicken with 14 ounces of starch; and dissolve in the hot paste 2 ounces of sulphate of copper.

3. *Violet.*—Take 1 gallon of iron liquor of 1·04 spec. grav.;
2 ounces of cream of tartar; 2 ounces of nitre; 2 ounces of copperas;
1 ounce of alum: dissolve, and mix the solution with
1 gallon of gum water, containing 6 lbs. of gum.

4. *Puce.*—Half a gallon of red mordant; half a gallon of iron liquor of 1·07;
7 ounces of starch for thickening; color with logwood.

Manipulation of the above colors.—Print on the black, then the puce, next the violet, and lastly the red. Dry in the hot flue, and 48 hours after the impression, wash away the paste. The copper employed for dyeing is of a square form: a boil is given with bran, at the rate of 4 lbs. per piece of the *foulards:* cold water is added to lower the temperature to 130° F. The pieces must be entered with the printed surface undermost, and winced for half an hour, taking care to keep them expanded and well covered with the liquor: they are then taken out and rinsed. When grounds are to be made on the foulards, 2 ounces of sumach must be added per piece.

Maddering.—Suppose 48 pieces are to be grounded with madder. 12 pounds of madder must be put into the copper, 1 pound of sumach, and 6 pounds of bran; the bath must be tepid when the pieces are entered: it must be heated to 104° F, 20 minutes, and to the boiling point in an hour aud a half. The goods must be briskly winced all the time, and finally turned out into cold water.

When they come out of the madder bath they are much loaded with color. They are cleared by a boil of half an hour in bran, then turned out into cold water, and rinsed. A bath must be now prepared with 3 pounds of soap, 1 ounce of solution of tin, and 2 pailsful of bran, in which the goods are to be boiled for half an hour, rinsed, and passed through a very dilute sulphuric acid bath. Then rinse, and dry. By following this process, a light salmon ground is obtained.

II. *Steam colors upon silk.*—The same plan of operations may be adopted here as is described for calico-printing; the main difference being in the method of mordanting the goods. After boiling in soap water, in the proportion of 4 ounces per pound of silk, the goods are washed in cold water, then in water at 140°; rinsed, passed through weak sulphuric acid, rinsed, squeezed between rollers, and steeped in a bath containing 8 ounces of alum per gallon, for four hours with occasionally wincing. They are now rinsed and dried. The subsequent treatment resembles that of steam-color printed cottons.

Yellow.—Take 1 gallon of a decoction, made with 4 lbs.

of Persian berries: dissolve in it 8 ounces of salt of tin (muriate), and 4 ounces of the nitro-muriatic solution of tin. Thicken with 2 pounds of gum.*

Black.—Take a gallon of decoction, made with 4 lbs. of logwood, with which

14 ounces of starch are to be combined: mix in

2 ounces of galls; boil, and pour the color into a pipkin containing

2 ounces of tartaric acid; 2 ounces of oxalic acid, both in powder, and

2 ounces of olive oil. Stir the color till it is cold, and add

8 ounces of nitrate of iron, and 4 ounces of nitrate of copper.

Printing of foulard pieces. The tables which serve for the impression of silk goods are so constructed as to receive them in their full breadth. Towards the part between the color or sieve tub and the table, the roller is mounted upon which the piece is wound. This roller A, B, fig. 42, has a groove, C, cut out parallel to its axis. Into this a bar is pressed, which fixes the end of the piece. The head B, of the roller is pierced with several holes, in which an iron pin passes for stopping its rotation at any point, as is shown at B. At the other end of the table there is placed a comb, fig. 43, which is supported by pivots A, B, at its ends. The teeth of the comb are on a level with the cloth.

Fig. 42.

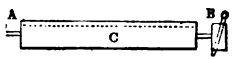
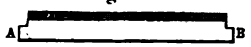


Fig. 43.



The piece is arranged for printing as follows:—It is unwound, and its end is brought upon the teeth of the comb, and made to pass into them by slight taps with a brush. It is now stretched, by turning round the roller, and fixing it by the pin-handle. After tracing the outline, the printing blocks are applied. Care should be taken, in the course of printing,

* Red, violet, lilac, &c., are the same as for steam-colors upon cotton. Topical colors are also applied without mordanting the silk beforehand. In this case a little muriate of tin is introduced.

always to fix the teeth of the comb in the middle line between two handkerchiefs. The operation of grounding-in is much facilitated by this plan of extension.

The pieces are washed in running water, and must be rapidly dried. The subsequent dressing is given by gum tragacanth: they are dried upon a stretching frame, and then folded up for the market.

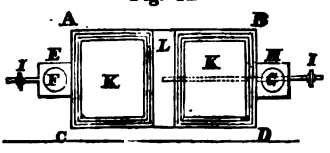
III. *Mandarining of silk stuffs and chalys.*—This style of printing depends upon the property which nitric acid possesses of giving to silk and woolen goods a yellow color.

The first step is the scouring with a soap boil, as already described.

The designs are printed-on as also above described.

The "swimming" or color tub is usually double, and serves for two tables; instead of being placed at the end of the table, it is put between two, and, consequently, behind the printer. It is formed of a copper chest, fig. 44, A, B, C, D, in which steam may circulate, introduced by the pipe, I; the excess being allowed to escape, as also the water of condensation. The frame is placed in the hollow box K, K. Between two such frames there is a plate of copper, L, which closes the box; it serves for laying the plates in order to keep them hot. At E, and H, are prolongations of the box, in which are set the vessels F, G, for holding the reserve paste.

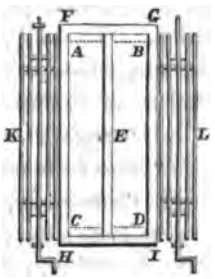
Fig. 44.



Preparation of the reserve or resist paste.—Melt in a kettle 2½ lbs. of rosin; 1 lb. of suet; mix well, and put it into the basins, F, G. By means of steam the reserve is kept melted, as well as the false color upon which the sieve floats. The piece of silk being laid upon the table, and the reserve spread upon the frame, the printer heats his block, which should be mounted with lead, if the pattern will permit, upon the little table, L. He takes up the color from the frame, and transfers it instantly to the piece. He must strike the block lightly, and then lift it, lest by its cooling, it might stick to the silk. When the table pattern is completed, he dusts it

over with sand, and proceeds to another portion of the silk. The piece must not be taken out of the stretch till it is quite dry, which requires usually 6 hours. Let us consider first the most common case, that of a white upon an orange ground. We shall afterwards describe the other styles, which may be obtained by this process. The piece, being printed and dry, must next be subjected to the *mandarining* operation.

Fig. 45.



The apparatus here employed consists of a sandstone trough, A B C D, fig. 45. Upon the two sides, A C, B D, of this trough are fixed two wooden planks, pierced with a hole an inch from the bottom to receive the roller E, under which the piece passes. In this trough the acid mixture is put. That trough is put into a wooden or copper trough, F G H I. Into the latter, water is put, which is heated by means of steam, or a convenient furnace. Before and behind are placed two winces, or reels, K, L; one serves to guide the piece in entering into the trough, and the other in its leaving it. The piece falls immediately into a stream of cold water, or, failing that, into a large back, containing a mixture of chalk and water. The two winces are moved by handles: the velocity is proportioned to the action of the acid. The wince L ought to be higher than K, to allow the acid to drain off. Fig. 46 shows a section of the apparatus.

Fig. 46.

The temperature of the acid mixture ought to be maintained between 95° and 100° F.; for if it be raised higher, the resist would run the risk of melting, and the impression would become irregular and blotty.

The proportions of the acid mixture are the following:—

1 gallon of water; and 1 gallon of nitric acid, of spec. grav. 1·288, which may be increased with the strength of the silk. It should be a little weaker for chalys. For the strong

greens it may be 2 measures of acid of 1·288 to 1 measure of water. The duration of the passage through the acid should be 1 minute at most.

Mixture of orange color, and clearing away of the resist.—The goods, on coming out of the mandarining apparatus, are rinsed in running water; then boiled in soap water, quickened with a little soda, at the rate of 2 lbs. of the former and 4 oz. of the latter for a piece of 30 yards. They must be worked by the wince for half an hour. They are now rinsed in cold water, then passed through hot, again rinsed, and dried. We shall give some examples of the mode of manufacture, which is undoubtedly one of the most curious applications of chemical ingenuity.

I. *Orange ground with white figures.*

1. Print-on the fat reserve; 2. mandarine; 3. brighten the orange, and clear.

II. *Orange ground with blue figures.*

1. Dip in the indigo vat as for calico; 2. print-on the fat resist to preserve the blue; 3. mandarine; 4. clear, and brighten the orange by the boil.

III. *Orange ground, with blue and white figures.*

1. Print-on the resist to preserve the white; 2. dip in the vat, rinse, and dry; 3. ground-in the fat resist to preserve the blue; 4. mandarine; 5. cleanse, and brighten.

IV. *Full green ground, and white figures.*

1. Print-on the resist; 2. mandarine, and rinse without drying; 3. dip in the blue vat; 4. cleanse, and brighten.

V. *Full green ground, and blue figures.*

1. Dip a pale blue, rinse, and dry; 2. print-on the fat resist; 3. mandarine, wash and dry; 4. dip full blue; 5. clean, and brighten.

VI. *Full green ground, with white and blue figures.*

1. Print-on the resist; 2. dip a pale blue, and dry; 3. ground-in the fat resist; 4. mandarine and rinse; 5. dip a full blue; 6. clean, and brighten.

VII. *Full green ground, with white, blue, and orange figures.*

1. Print-on the fat reserve; 2. dip a pale blue, and dry; 3. ground-in the reserve; 4. mandarine, rinse, and dry; 5. ground-in the reserve; 6. dip a full blue; 7. clean, and brighten.

If blue grounds with white figures be wanted, the resist

must be applied, and then the goods must be dipped in the blue vat: the resist is afterwards removed by a boil in soap-water.

The above processes are applicable to chalys.

The property which nitric acid possesses of staining animal matters yellow, such as the skin, wool, and silk, is here applied to a very elegant purpose.

Of the bronze or solitaire style by mandarining.—The mandarining mixture is

1 gallon of nitric acid, of 1·17 spec. grav.; mixed with 3 pints of solution of nitrate of iron, of spec. grav. 1·65. If the quantity of nitrate of iron be increased, a darker tint will be obtained. The temperature of the mixture should be 94° F. The pieces, after mandarining, are let fall into water, and steeped for an hour.

In order to raise the bronze, and clear away the fat resist, the goods must be boiled in a bath of soap and soda, as described for orange.

I. *Bronze ground, with white figures.*

1. Print-on the fat resist; 2. dip in the blue vat, and dry; 3. pad in a decoction of logwood, of 4 lbs. per gallon; dry, taking care to turn over the selvages; 4. mandarine, and steep in water for an hour; 5. cleanse, and pass through soap.

II. *Bronze ground, with blue figures.*

1. Dip in the blue vat, and dry; 2. print-on the fat resist; 3. pad in the above decoction of logwood, and dry; 4. mandarine, and steep an hour; 5. cleanse, and brighten.

III. *Bronze ground, with white and blue.*

1. Print-on the fat resist; 2. dip in the blue vat, and dry; 3. ground-in the fat resist; 4. pad in the logwood liquor, and dry; 5. mandarine, and steep for an hour; 6. cleanse, and give the brightening boil with soap.

This style of manufacture may be executed on chalys; and is capable of producing beautiful effects, which will in vain be sought for by other means.

With silks, advantage may be derived from various metallic solutions which possess the property of staining animal substances; among which are nitrate of silver, nitrate of mercury, and muriate of iron. The solutions of these salts may be thickened with gum, and printed-on.

An orange upon an indigo vat ground.—After the blue ground has been dyed, orange figures may be produced by printing-on the following discharge paste :—

1 gallon of water, made into a paste with 1 pound of starch; when cold, add to it from 16 to 24 ounces of nitric acid, of spec. grav. 1·288.

An orange upon a Prussian-blue ground.—The dye is first given by Prussian blue in the ordinary way, and then the following discharge is printed-on :—

A caustic ley being prepared, of 1·086 specific gravity, dissolve in a gallon of it 2 pounds of annotto, and thicken with 3 pounds and a quarter of gum. Two days after the impression of this paste, pass the goods through steam, and wash them in running water. With these two designs, the logwood and gall-black, formerly described, may be associated, to produce a rich effect.

*Stains.**—When stains are produced by mordants upon spots where no color is to come, the operator must, before dunging the goods, apply a little lime-juice, or tartaro-oxalic acid discharge paste, to the place. If the stains are not perpeived till after the maddering, it will then be necessary to apply to them first a strong solution of chloride of lime, with a pencil, next a solution of oxalic acid (mixed with a little muriatic acid) with another pencil, and immediately afterward wash with water. All madder stains will be effaced by this means.

Rust stains are removeable by a mixture of oxalic and muriatic acids.

Indigo stains by the combined action of chloride of lime and muriatic acid.

Topical yellow stains, or yellow dyes, by the same combination.

Metallic greens and *Scheele's green* by the muriatic acid alone.

Chrome green and *Prussian blue.*—The blue may be taken out by a caustic alkali, after which the goods must be washed : the residuary rust stain may be removed by a mixture of oxalic and muriatic acids. The above methods refer

* See chapter IV., Part V.

† After fixing the color by steam, the orange is brightened with a soap boil.

to cotton and linen. The stains on silk and woolen stuffs should be removed before fixing the colors by the soap boil; which may generally be done by scratching with the finger, with the aid of a little water.

Clouding or *Chineing*.—The art of clouding silk has been practiced in France since the year 1510, when it was first introduced into Lyons by an Italian weaver, but until lately has ever been conducted in a very rude manner.

The technical term to "cloud," denotes the partial coloring of the threads previously to their being woven, producing an irregular, speckled appearance, or assuming a more definite design, but always characterized by a softened, shaded, or irregular outline.

In 1839 a process, then in active operation at Lyons, was introduced into England by Mr. G. T. Kemp, which afterwards proved to be nearly identical with that described in Mr. Walon's patent, taken out in 1825. In 1840, and following years, the process was very generally applied to the manufacture of broad silks, ribands, shawls, and other articles of silk, as also to mixed fabrics of cotton, linen, and wool.

The process is as follows:—The warp, generally white, is "beamed on" and "twisted in," in the usual way. The silk, as stretched in the loom, is then carefully "picked," or cleared from rough, or hairy, threads, and other imperfections. A firm heading, or "tab," about two inches in width, is first woven, after which a small rod is introduced into the shed, for the purpose of attaching the warp to the "cloth beam." "Cross-strings" are then woven in, to enable the workman to twist the warp in with facility after being printed. The weaver next proceeds to draw about 12 inches of the warp through the harness, and weaves a strip of plain cloth, containing about 80 picks, or shots, to the inch. After winding about 12 inches of the warp on the cloth roller, he repeats the strip of plain cloth, continuing the process, picking or clearing the warp throughout, until the whole warp has been thus prepared, the end of which he secures with a firm heading, as at the beginning. If a fine and delicate pattern is required, the interval of 12 inches cannot be exceeded with safety; but

when the pattern is large, and the outline irregular, a longer space may be left between the strips. The cloth roller, which need not be more than three inches in diameter, must have wooden or cast-iron heads, to support the warp when it begins to rise on the beam. It is important here to remark, that the warping and beaming should be performed in the best manner, and the picking, or clearing, the warp very carefully watched, as it is obvious that mending any threads *after* the printing, must inevitably injure the work.

The object of forming the temporary fabric, just described, is to keep the threads of the warp in their proper positions during the subsequent operations of printing, steaming, washing, drying, and weaving.

The cloth roller with the warp thereon being delivered to the printer, he affixes it in a frame, in which it is supported horizontally on its axis; he then draws off a sufficient length of the partially woven warp, which is passed over the printing table, at the end of which it is attached to two parallel lengths of tape, about fifteen yards long, which pass over a series of rollers to an empty beam, which may be termed the *printer's beam*, to which they are attached, and which is placed near to, and *above* the cloth roller, so as to enable the printer, at the same time, to let off the necessary length of warp from the cloth roller, and wind a corresponding length upon the printer's beam, as the printing of the warp proceeds.

When extended over the table, the warp is printed with blocks in the ordinary manner, being kept close down to the surface of the table, by means of the roller at each end, under which the warp passes, and which rollers are capable of being raised or depressed, as circumstances require. The printing table is covered with a blanket, surmounted with an oiled or painted cover, between which and the warp, a piece of calico is spread, of which a *fresh length* must be substituted every time a table-length of the warp has been printed. The neglect of this would cause the superfluous color, received by the calico, to smear the warp.

Each table-length of warp, when printed, is liberated from the table by raising the moveable rollers, and is then drawn

by the tapes to the printer's beam. During this passage, of about fifteen yards in length, as before stated, a sufficient time is given for drying, to prevent any smearing, or marking off, when rolled on the printer's beam. To assist the drying, a certain degree of artificial heat, with good ventilation, is maintained.

The warp, thus printed, is wound off the printer's beam, and formed into a large "skein-ball," of from eight to ten feet in circumference, and next undergoes the operation of *steaming* to fix the coloring matter, great care being taken to prevent any *condensation of moisture* on the silk.

It is then thoroughly washed in a stream of cold water, to remove the extraneous coloring matter, and also the thickening ingredients with which the color is mixed. During washing, the silk is protected by a covering of loose canvass in which it is sewn up.

After drying the warp is given to the weaver to be rewoven into the ultimate figured cloth required. In winding the warp again on the warp roller, the ordinary means of spreading it, by passing it through a coarse "ravel," or "wraith," are inapplicable, on account of the strips of cloth which have been woven across it; the process, however, is readily effected by stretching these strips to their full extent, and thus guiding it on with the hand. The weaver now pursues the ordinary method of manufacturing the web, drawing out as he proceeds, the weft which had been woven in, to form the small strips of cloth before mentioned.

GILDING SILKEN FABRICS BY CHEMICAL MEANS.—Some years ago the Society for the Encouragement of Arts, at Berlin, offered a reward of several thousand francs to any person who should succeed in *gilding silken threads by chemical means*, in such a manner that the gilding shall be solid (*i. e.* not liable to wear off easily), and not only not deterioated, as regards its wear, but in a fit state to be woven in the same manner as metallic wires.

Although the experiments made for this purpose have completely failed, as far as regards the gilding of threads, yet Dr. Bretthager succeeded in obtaining upon silken fabrics a

very splendid coat of gilding. As regards the choice of fabric to be gilt, the preference should be given to those of the most uniform texture and glossy appearance. The manner of operating is as follows :—

1. *Dyeing of the silk.*—This operation is performed with an aqueous solution of chloride of gold, which must not contain the least portion of free acid. A chlorate of gold, perfectly free from acid, is prepared in the following manner :—

A quantity of gold (a ducat for example) is dissolved in *aqua regia*, which consists of a mixture of two parts of chlorhydric acid, and one part of nitric acid of commerce; the liquor is carefully decanted from the precipitated chlorate of silver, and evaporated to dryness at a gentle heat; the residuum is a chlorate of gold, containing no free acid. It is then dissolved again in pure water, and this solution is used for the dyeing process, and which must be effected at a boiling heat.

2. *Bringing out the metallic lustre.*—This is effected by means of phosphohydric gas. The process is as follows :—

This fabric is brought in a damp state, into an atmosphere highly charged with the gas. During the operation the fabric must be kept damp, and the gas allowed to disengage itself freely. Although the fabric must not be dry, it should not be so wet as to allow the water to run therefrom, as the pellicle of gold would be carried away by the infiltration of the water, thus causing flaws and defects; the action of the gas must consequently be prolonged, as the operation takes effect first upon the surface of the fabric; and the coating of gold, thus formed, creates an obstacle to the action of the gas in the interior. The chloride of gold remaining in the fabric becomes ultimately, by the action of the light, of a purple or violet color, and thus injures the gilding. In order to avoid this, it is necessary, besides the phosphoretted hydrogen, which is present in sufficient quantity, to introduce steam into the chamber or box where the fabric is spread out in the manner most favorable to the operation, by which means the requisite degree of dampness is kept up. Under the chamber is placed a vessel, of suitable size, with a large opening for the escape of the gas contained therein, and to prevent the introduction of any extraneous matters it may contain into the chamber; a plate of metal is placed at a short distance above the opening, and at one side of the chamber the necessary apparatus for injecting steam therein is fixed.

As soon as the disengagement of the gas commences, a slight metallic lustre appears upon the silk, which gradually augments until all the gold is brought out.

APPENDIX.

A.

ACCIDENTAL COLORS.—Colors depending on some affection of the eye, and not belonging to light itself, or any quality of the luminous object. If we look for a short time steadily with one eye upon any bright-colored spot, as a wafer on a sheet of paper, and immediately after turn the same eye to another part of the paper, a similar spot will be seen, but of a different color. If the wafer be red, the imaginary spot will be green; if black, it will be changed into white; the color thus appearing being always what is termed the *complementary color* of that on which the eye was fixed.

ACETATE.—Any saline compound of which the acetic is the acid constituent; as acetate of soda, of iron, of copper, &c.

ACETATE OF ALUMINA.—(See *Red Liquor;* also *Mordants*, chapter I, Part III.)

ACETATE OF LEAD (sugar of lead) may be obtained by exposing metallic lead to the action of acetic acid, either as a liquid or as a vapor, and to the air: a portion of the acid is decomposed, and carbonate of lead is formed, which is then easily decomposed by another portion of the acid; the latter combining with the lead, forms acetate of lead, and the carbonic acid is evolved.

Acetate of lead is prepared for extensive purposes by a variety of modes. The first we mention, is to immerse a number of sheets of lead in vinegar, so arranged that the uppermost sheets are exposed to the action of the air. When they become covered with the crust of carbonate, they are shifted to the bottom of the vat, where the acid decomposes the carbonate and forms acetate, while the succeeding sheets are being exposed to the same course of action.

Another process is to expose sheets of lead to the vapors of vinegar: the carbonate formed is collected and immersed in strong vinegar. In both these processes, when the acid appears to be saturated, or when it

ceases to decompose the carbonate, the solution is drawn into proper vessels and allowed to crystalize.*

Another process for preparing acetate of lead is to dissolve litharge in strong vinegar to saturation. This is done by gradually sprinkling the litharge in a vessel of vinegar subjected to a boiling heat; the vinegar is kept stirring, to prevent the adhesion of the litharge to the bottom and sides of the boiler. When a sufficient quantity is dissolved, a moderate quantity of cold water is poured into the solution, reducing it a little below the boiling point, and then it is allowed to settle; the clear fluid is drawn off into a separate vessel and allowed to crystalize. If the solution be colored, it is whitened by filtration through bone black. Common unrectified wood vinegar or pyroligneous acid, is much used for the preparation of acetate of lead for the dye-work. It is known in the dyehouse by the appellation of *brown sugar*.

Basic salts or sub-acetates, are made by boiling common acetate of lead with litharge. The tri-basic acetate, *a combination of three of lead to one of acid*, is the best salt for dyeing *orange*, *deep yellow*, and *amber*. It is prepared in the dye-house *by boiling a solution of sugar of lead with litharge, and adding to this a little lime*. The proportions, however, vary in different dyehouses. Those which should be employed to produce the tri-basic acetate, *are six parts of crystalized acetate of lead, eight of litharge, and thirty of water, boiled till the litharge is dissolved*. The addition of lime causes a loss, as the lime combines with part of the acetic acid forming acetate of lime, which, if these proportions have been used, would prevent some of the litharge from being dissolved. If the mixture be not long enough boiled, or if the proportion of litharge be too small, *the adoption of lime insures the conversion of the acetate of lead present into the tri-basic state, though it is to be observed, that this will be at the expense of a portion of the lead intended for producing the color*. We have experienced much annoyance from this source; and it is well known in the trade, that when the lead is hastily prepared for orange, *it is a cause of great anxiety, and the color obtained is frequently defective*. As this is rather an important point in the economy of the dyehouse, we shall explain our view of the matter. If the proportions recommended above be used, the following is the result: and we must bear in mind that while the oxide of lead forms the basis of the dye, the acid merely

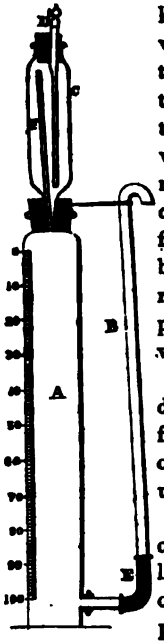
* Stoneware vessels, with salt glaze, answer best for crystallizers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation*. The crystals are to be drained, and dried in a stove-room very slightly heated. It deserves remark, that linen, mats, wood, and paper, imbued with sugar of lead, and strongly dried, readily take fire, and burn away like tinder. When the mother waters cease to afford good crystals, they should be decomposed by carbonate of soda, or by lime skilfully applied, when a carbonate or an oxide will be obtained, fit for treating with fresh vinegar. The supernatan acetate of soda may be employed for the extraction of pure acetic acid

holds the lead in solution. The six pounds of acetate of lead is composed of four lbs. oxide of lead, and two lbs. acetic acid; but when the eight pounds of litharge is dissolved or, as dyers say, *taken up*, the tri-basic salt will consist of 12 lbs. of oxide of lead and 2 lbs. of acetic acid; that is, every ounce of acid holds in solution twelve ounces of oxide of lead. Now, if a little lime, as we have often remarked, be put in along with the litharge, the result will be as follows: Suppose that 50 lbs. of cotton is to be dyed *orange*, and that it consumed the 6 lbs. acetate of lead prepared as now stated, to give it a good color. If 1½ ounces of lime be mixed in, it will combine with three ounces of acid: in this way 36 ounces of oxide of lead is not taken up, and is therefore ineffective in the production of the color; while at the end of the process, the dyer is surprised to find his color poor. We may notice that lead in the basic state is not held in combination by a very great affinity, and thus a very little counteractive influence precipitates it. The presence of sulphates or carbonates in the water, which almost all water contains, precipitates the lead; hence the reason that when the clear acetate solution is poured into a tub of water, the contents become milk-white by the formation of an insoluble carbonate. This is all lost for the time being, as it is rendered insoluble and useless as a dye. Every ounce of carbonate renders useless 5 ounces of lead. The softest water should be used for the lead solution, as, for example, the condensed steam from an engine.

ACIDIMETRY may be exactly performed by measuring in the cylindric gasmeter the volumes of carbonic acid gas disengaged from pure bicarbonate of potash or soda, by a given weight of any acid, taking care to use a small excess of the salt. Thus, for example, 16·8 grains of dry and 20⅔ of hydrated sulphuric acid disengage 10,000 water grain measures of gas from bicarbonate of potash. Therefore, if 20⅔ grains of a given sulphuric acid be poured into the flask of fig. 47, upon about 50 grains of the bicarbonate, powdered and covered with a little water, it will cause the evolution of a volume of gas proportioned to its strength. If the acid be pure oil of vitriol, that weight of it will disengage 10,000 grain measures of gas; but if it be weaker, so much less gas—the centigrade measures of which will denote the per-centage value of the acid. If the question be put, how much dry acid is present per cent. in a given sulphuric acid, then 16·8 grains of the acid under trial must be used: and the resulting volume of carbonic acid gas on the scale will denote the per-centage of dry acid.*

* For nitric acid, we should take 22·6 grains; for hydrochloric or muriatic acid, 15·24; for acetic acid, 21·6; for citric acid, 24·6; for tartaric acid, 28 grains; then in each case we shall obtain a volume of carbonic acid gas proportioned to the strength and purity of these acids respectively. The nitric, hydrochloric, and acetic acids are referred to in their anhydrous state; the tartaric and citric in their crystalline.

Fig. 47.

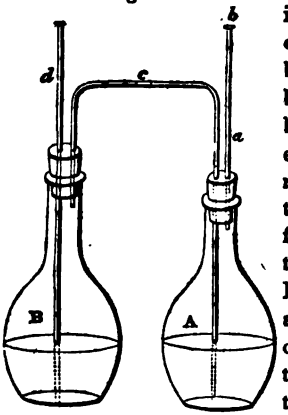


A, is a cylinder two inches in diameter, and 14 inches long. It contains, as above stated, 10,000 grains of water in the graduated portion; O, or zero being at the top. It has a tubulure in the side close to the bottom, through the cork of which a short tube passes tight, and is connected to a collar of Indian rubber, E, which serves for a joint to the upright tube, B, resting near its open upper end in a hooked wire. Through the cork in the mouth of the cylinder, the taper tail of the flask, C, passes air-tight. The small tube, F, open at both ends, is cemented at bottom into the tail of C, and rises to the shoulder of the flask. The cork of C, is perforated, and receives air-tight the taper tube, D, which can also be closed with the stopcock.

The new German method of *acidimetry* consists in determining how much carbonic acid gas is disengaged from a standard bicarbonate of soda, by a given weight of any acid. The twin flask represented in fig. 48, is used.

A, must have a capacity of from two ounces to 2½ ounces of water; it is advisable that B should be a little smaller, say of a capacity of about 1 to 1½ ounces. Both flasks are closed by means of doubly perforated corks. These perforations serve for the reception of the tubes, *a*, *c*, and *d*. *c*, is a tube bent twice at right angles, which enters at its one end just into the flask, A, but descends at its other end, near to the bottom of B. These tubes are open at both ends when operating; except the top end, *b*, of the tube, *a*, which is closed by means of a pellet of wax. The substance to be examined is weighed and put into the flask, A, into which water is then poured to the extent of one-third of its capacity. B, is filled with common English sulphuric acid to about half its capacity, and a sufficient quantity of soda is put into a test-tube, which is suspended upright with a silk thread fastened by the pressure of the cork to the mouth of the flask. On letting the thread loose, the test-tube falls, and the cork being instantly replaced, the whole gas evolved is forced to pass through the sulphuric acid in B, and there to deposit its moisture.

Fig. 48.



ACIDULATED.—Tinged with an acid; made slightly sour.

ADULTERATION.—The debasing of any product of manufacture, especially chemical, by the introduction of cheap materials. The art of ascertaining the genuineness of the several products used by dyers, calico-printers, &c., is described under the specific objects of manufacture in the body of the work.

AFFINITY.—The chemical term denoting the peculiar attractive force which produces the combination of dissimilar substances; such as of an alkali with an acid, or of sulphur with a metal.*

ALIZARINE.—From Ali-zari, the commercial name of madder in the Levant; a peculiar coloring principle obtained from madder.—(See chapter III, Part I, article *Madder*.)

ALKALI.—A class of chemical bodies, distinguished chiefly by their solubility in water, and their power of neutralizing acids, so as to form saline compounds. The alkalies of manufacturing importance are, ammonia, potash, soda, and quinia. These alkalies change the purple color of red cabbage and radishes to a green, the reddened tincture of litmus to a purple, and the color of turmeric and many other yellow dyes to a brown. Even when combined with carbonic acid, the first three alkalies exercise this discoloring power, which the alkaline earths, lime, and barytes, do not. The same three alkalies have an acrid, and somewhat urinous taste; the first two are energetic solvents of animal matter; and the three combine with oils, so as to form soaps. They unite with water in every proportion, and also with alcohol; and the first three combine with water after being carbonated.

ALKALIMETER.—An instrument for measuring the alkaline force or purity of any of the alkalies of commerce. It is founded on the principle, that the quantity of real alkali present in any sample, is proportional to the quantity of acid which a given weight of it can neutralize.

ALKANA, is the name of the root and leaves of *Lawsonia inermis*, which have been long employed in the East, to dye the nails, teeth, hair, garments, &c. The leaves ground and mixed with a little limewater, serve for dyeing the tails of horses in Persia and Turkey.

ALKANET, the root of *(Anchusa tinctoria.)* A species of bugloss, cultivated chiefly in the neighborhood of Montpelier. It affords a fine red color to alcohol and oils; but a dirty red to water. Its principal use is for coloring ointments, cheeses, and *pommades*. The spirituous tincture gives to white marble a beautiful deep stain.

ALUM.—In the alum works on the Yorkshire coast, 8 different liquors are met with. 1st. "Raw liquor." The calcined alum shale is steeped in water till the liquor has acquired a specific gravity of 9 or 10 pennyweights, according to the language of the alum-maker.

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* See *Equivalents Chemical.*

2d. "Clarified Liqour." The raw liquor is brought to the boiling point in lead pans, and suffered to stand in a cistern till it has cleared: it is then called clarified liquor. Its gravity is raised to 10 or 11 pennyweights.

3d. "Concentrated Liquor." Clarified liquor is boiled down to about 20 pennyweights. This is kept merely as a test of the comparative value of the potash salts used by the alum-maker.*

4th. "Alum Mother Liquor." The alum pans are fed with clarified liquor which is boiled down to about 25 or 30 pennyweights, when a proper quantity of potash salt in solution is mixed with it, and the whole run into coolers to crystalize. The liquor pumped from these rough crystals is called "alum mothers."

5th. "Salts Mothers." The alum mothers are boiled down to a crystalizing point, and afford a crop of "Rough Epsom," which is a sulphate of magnesia and protoxide of iron.

6th and 7th. "Alum Washings." The rough crystals of alum (No. 4), are washed twice in water, the first washing being about 4 pennyweights, the second about 2½, the difference in gravity being due to mother liquor clinging to the crystals.

8th. "Tun Liquor." The washed crystals are now dissolved in boiling water, and run into the "roaching tuns" (wood vessels lined with lead) to crystalize. The mother liquor of the "roach alum" is called "tun liquor;" it is, of course, not quite so pure as a solution of roach alum in water.

ALUMINA.—When a solution of ammonia is dropped into a solution of alum, a white precipitate falls, which, thoroughly washed, dried, and heated, is pure aluminous earth. There are two properties of this earth which render it of great importance in the arts; one is, that it forms a plastic mixture with water, and, though it is not the predominant ingredient, yet it confers the valuable property of plasticity upon all natural clays, which enables them to be moulded into the various forms of pottery and earthenware; the other is the remarkable affinity of alumina for coloring and extractive matter, whence its use in the arts of dyeing and calico-printing.—(See *Mordants*, chapter I., Part III.)

ALUMINATE OF POTASH.—Another preparation of alumina much employed as a mordant for cotton goods, is the solution of alumina in caustic potash, known as the aluminate of potash. The following method of preparing this solution is recommended by M. Kœchlin-Schouch:—

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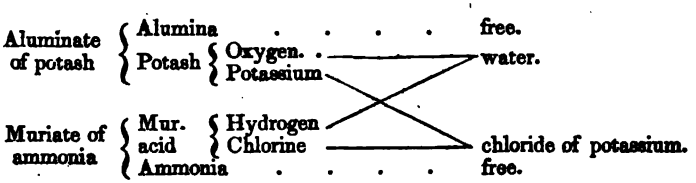
* The alum-maker tests his samples of potash salts comparatively by dissolving equal weights of the different samples in equal measures of alum liquor at 20 pennyweights, heated to the boiling point, and weighing the quantity of alum crystals produced on cooling.—(See chapter I, Part III.)

A solution of caustic potash is first made by boiling for half an hour a mixture of eighty pounds of carbonate of potash, thirty-two pounds of quick-lime, and forty gallons of water. The caustic ley being allowed to settle, thirty gallons are decanted and evaporated down to the density 35° Baumé (60° Twaddell), and 60 pounds of powdered alum are added to the boiling liquid. As the solution cools, a quantity of sulphate of potash is deposited in crystals.

When a piece of cloth impregnated with the aluminate of potash is suspended freely in the air, the carbonic acid of the atmosphere seizes upon the caustic potash which holds the alumina in solution, causing the formation of carbonate of potash and precipitation of alumina. If the apartment in which cottons printed with the aluminate of potash are suspended is imperfectly ventilated, after a short time not a trace of carbonic acid can be detected in the atmosphere by the ordinary test of lime-water; hence the necessity of paying particular attention to the means of producing a proper ventilation in the "hanging" or "ageing" room, if the complete precipitation of the alumina during that stage of the process is required.

The time of hanging the mordanted goods, however, is seldom prolonged sufficiently to allow of the complete decomposition of the aluminate of potash. This is insured by afterward passing the cloth through a dilute solution of muriate of ammonia, which immediately determines the complete precipitation of the alumina. The reactions which take place when a solution of aluminate of potash is mixed with a solution of muriate of ammonia are expressed in the following diagram:—



The aluminate of soda may be prepared in the same manner and used for the same purposes as aluminate of potash. It is said that no difference is perceptible between the effects obtained by aluminate of potash, and those by aluminate of soda.

The other simple preparations of alumina which are occasionally used as mordants are, nitrate of alumina, chloride of aluminum, and tartrate of alumina. Of these, the most extensively employed is the nitrate, which may be prepared of sufficient purity for the use of the dyer and calico-printer by mixing concentrated solutions of equal weights of alum and nitrate of lead, when sulphate of lead is formed and precipitated, and nitrate of alumina remains in solution.*—(See *Red Liquor*.)

* Parnell.

AMMONIA.—This important compound is chiefly produced artificially. It exists, combined with acids, in some of the saline products of volcanos, and, in very small quantities, it is discoverable in sea-water. The salts of ammonia are distinguished as a class, by being all volatile, or decomposable by a strong heat. If the acid with which this base is combined be volatile, the salt will be sublimed without change; but if it be fixed, the ammonia will fly off, and the acid remain. Their taste is, in general, hot and biting; and they all emit the well-known smell of the volatile alkali, when mixed with caustic lime. Ammonia in its purest state, is a highly pungent gas, possessed of all the mechanical properties of the air, but very condensable with water. It consists of 3 volumes of hydrogen and 1 of azote condensed into two volumes; and hence its density is 0·591, atmospheric air being 1·000. By strong compression and refrigeration it may be liquefied into a fluid, whose specific gravity is 0·76 compared to water 1·000.—(See *Sal Ammoniac.*)

ANALYSIS.—In chemistry, this term is applied to the resolution of compound bodies into their elements. It is either qualitative or quantitative. Qualitative analysis consists in the determination of the component parts, merely as respects their nature, and without reference to their relative proportions: it is an imperfect, and often a very easy operation, as compared with quantitative analysis, by which we determine not merely the components of a compound, but their relative proportions: to effect this, much scientific skill and practical dexterity are required, more especially in the identification of new substances. The theory of definite proportionals, or the Atomic Theory, as it is usually called, has materially facilitated many analytical processes, and is especially valuable in furnishing an unerring test or criterion of the general accuracy of the results.

In reference to chemical analysis generally, but more especially as regards organic products, we often employ the terms proximate and ultimate analysis: the former referring to the immediate combinations which form the subject of experiment; the latter to their final resolutions into elementary principles. Thus, in regard to sulphate of lime, it is resolved by proximate analysis into sulphuric acid and lime, and these are called its proximate elements; but sulphuric acid is itself a compound of oxygen and sulphur; and lime, of oxygen and calcium; oxygen, sulphur, and calcium, therefore, are the results of the ultimate analysis of sulphate of lime; and there are many theoretical points in chemistry dependent upon the views which are taken of the various groupings of these ultimate principles. Wheat flour is a compound of starch and gluten; starch is compounded of oxygen, hydrogen, and carbon; and gluten, of the same elements with the addition of nitrogen; so that the ultimate components of wheat, are oxygen, hydrogen, carbon, and nitrogen.

ANHYDROUS.—Without water; a term frequently applied to gases,

salts, alcohol, acids, and some other substances, to express their existence in the *dry* state.

AREOMETER OF BAUME.—This scale is much used by the French authors. The following table shows the Specific Gravity Numbers corresponding with Baume's Areometric Degrees :—

Liquids denser than Water.						Less dense than Water.			
Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.	Degrees.	Specific gravity.
0	1·0000	26	1·2063	52	1·5200	10	1·0000	36	0·8488
1	1·0066	27	1·2160	53	1·5353	11	0·9932	37	0·8439
2	1·0133	28	1·2258	54	1·5510	12	0·9865	38	0·8391
3	1·0201	29	1·2358	55	1·5671	13	0·9799	39	0·8343
4	1·0270	30	1·2459	56	1·5833	14	0·9733	40	0·8295
5	1·0340	31	1·2562	57	1·6000	15	0 9669	41	0·8249
6	1·0411	32	1·2667	58	1·6170	16	0·9605	42	0·8202
7	1·0483	33	1·2773	59	1·6344	17	0·9542	43	0·8156
8	1·0556	34	1·2881	60	1·6522	18	0·9480	44	0·8111
9	1·0630	35	1·2992	61	1·6705	19	0·9420	45	0·8066
10	1·0704	36	1·3103	62	1·6889	20	0·9359	46	0·8022
11	1·0780	37	1·3217	63	1·7079	21	0·9300	47	0·7978
12	1·0857	38	1·3333	64	1·7273	22	0·9241	48	0·7935
13	1·0935	39	1 3451	65	1·7471	23	0·9183	49	0·7892
14	1·1014	40	1·3571	66	1·7674	24	0·9125	50	0·7849
15	1·1095	41	1·3694	67	1·7882	25	0·9068	51	0·7807
16	1·1176	42	1·3818	68	1·8095	26	0·9012	52	0·7766
17	1·1259	43	1·3945	69	1·8313	27	0·8957	53	0·7725
18	1·1343	44	1·4074	70	1·8537	28	0·8902	54	0·7684
19	1·1428	45	1·4206	71	1·8765	29	0·8848	55	0·7643
20	1·1515	46	1·4339	72	1·9000	30	0·8795	56	0·7604
21	1·1603	47	1·4476	73	1·9241	31	0·8742	57	0·7656
22	1·1692	48	1·4615	74	1·9487	32	0·8690	58	0·7526
23	1·1783	49	1·4758	75	1·9740	33	0 8639	59	0·7487
24	1·1875	50	1·4902	76	2·0000	34	0·8588	60	0·7449
25	1·1968	51	1·4951			35	0·8538	61	0·7419

ARSENIATE OF POTASH is prepared, in the small way, by exposing to a moderate heat in a crucible, a mixture of equal parts of white arsenic and nitre in powder. After fusion, the crucible is to be cooled; the contents being dissolved in hot water, and the solution filtered, will afford regular crystals on cooling, According to M. Berzelius, they are composed of arsenic acid, 63·87; potash, 26·16; and water, 9·97. It is an acidulous salt, and is hence usually called the biarseniate, to denote that its composition is 2 atoms of arsenic acid, and 1 of potash. This article is prepared upon the great scale, in Saxony, by melting nitre and arsenious acid together in a cylinder of cast-iron. A neutral arseniate

also is readily formed, by saturating the excess of acid in the above salt with potash; it does not crystalize.

ARSENIC.—White arsenic dissolves in the alkalies, and combines with the metallic oxides, forming a class of salts called *arsenites*, an example of which has just been given above. They are all poisonous.

ASTRINGENTS.—The principal vegetable astringents, are described in chapter II., Part III., under the head of *Tannin and Gallic Acid*. See also *Mordants*, chapter I. of the same Part.

ATOMIC WEIGHTS or ATOMS, are the primal quantities in which the different objects of chemistry, simple or compound, combine with each other, referred to a common body, taken as unity. Oxygen is assumed by some philosophers, and hydrogen by others, as the standard of comparison. Every chemical manufacturer should be thoroughly acquainted with the combining ratios, which are, for the same two substances, not only definite, but multiple; two great truths, upon which are founded not merely the *rationale* of his operations, but also the means of modifying them to useful purposes. The discussion of the doctrine of atomic weights, or prime equivalents, belongs to pure chemistry; but several of its happiest applications are to be found in the processes of art, as pursued upon the greatest scale.—(See *Equivalents* and *Affinity*.)

B.

BASE.—By a base is meant an alkili, or a metallic oxide which has a tendency to unite with an acid and thus form a *salt*. Thus, potash is the base of nitre. or nitrate of potash; oxide of lead is the base of sugar of lead, or acetate of lead; soda is the base of sulphate of soda; and sodium is the metallic base of soda. Hence the distinction into salifiable and metallic bases.

BISMUTH is white, and resembles antimony, but has a reddish tint; whereas the latter metal has a bluish cast. It is brilliant, crystalizes readily in small cubical facets, is very brittle, and may be easily reduced to powder. Its specific gravity is 9.83; and by hammering it with care, the density may be increased to 9.8827. It melts at 480° Fahr., and may be cooled 6 or 7 degrees below this point without fixing; but the moment it begins to solidify, the temperature rises to 480°, and continues stationary till the whole mass is congealed. When heated from 32° to 212°, it expands $\frac{1}{710}$ in length. When pure it affords a very valuable means of adjusting the scale of high-ranged thermometers. At strong heats bismuth volatilizes, may be distilled in close vessels, and is thus obtained in crystaline laminæ. The nitrate of bismuth, mixed with solution of tin and tartar, has been employed as a mordant for dyeing *lilac* and *violet* in calico-printing.

BLUE VITRIOL (Blue-Stone or Sulphate of Copper), is prepared from the sulphuret in the same way as sulphate of iron, or copperas, which see. Its principal use in the dye-house is for dyeing Scheele's green. This color is produced by boiling the cloth in a mixture of arsenious acid and sulphate of copper, then passing it through an alkaline ley, or more commonly lime water, and so on alternately. Superior processes might be had recourse to for producing the same color; and indeed common humanity would dictate the complete abandonment of the process just described, as in several instances, the handling of goods dyed to this shade of green has terminated fatally.—See page 272, Princes' patent.

BRAN.—The husky portion of ground wheat, separated by the bolter from the flour. It is advantageously employed by calico-printers, in the clearing process, in which, by boiling in bran-water, the coloring matters adhering to the non-mordanted parts of maddered goods, as well as the dun matters which cloud the mordanted portions, are removed. A valuable series of researches concerning the operation of bran in such cases was made a few years ago by that distinguished chemist and calico-printer, M. Daniel Kœchlin Schouch, and published in the ninth number of the Bulletin de la Société Industrielle de Mulhausen. Nine sets of experiments are recorded, which justified the following conclusions:—

1. The dose of two bushels of bran for 10 pieces of calico is the best, the ebullition being kept up for an hour. A boil for the same time in pure water had no effect in clearing either the grounds or the figures.

2. Fifteen minutes boiling are sufficient when the principal object is to clear white grounds, but in certain cases thirty minutes are requisite to brighten the dyed parts. If, by increasing the charge of bran, the time of the ebullition could be shortened, it would be in some places, as Alsace, an economy; because for the passage of ten pieces through a copper or vat heated with steam, 1 cwt. of coal is consumed in fuel, which costs from 2½ to 3 francs, while two bushels of bran may be bought for one franc.

3. By increasing the quantity of water from 12 to 24 hectolitres with two bushels of bran, the clearing effect upon the ten pieces was impaired. It is therefore advantageous not to use too much water.

4. Many experiments concur to prove that flour is altogether useless for the clearing boil, and that finer bran is inferior for this purpose to the coarser.

5. The white ground of the calicoes boiled with wheat bran, are distinguishable by their superior brightness from that of those boiled with rye bran, and especially with barley bran; the latter having hardly any effect.

6. There is no advantage in adding soap to the bran boil; though a little potash or soda may be properly introduced when the water is calcareous.

7. The pellicle of the bran is the most powerful part, the flour and the starch are of no use in clearing goods, but the mucilage which forms one-third of the weight of the bran has considerable efficacy, and seems to act in the following way. In proportion as the mucilaginous substance dissolves the coloring and tawny matters upon the cloth, the husky surface attracts and fixes upon itself the greater part of them. Accordingly, when used, bran is digested in a weak alkaline bath, it gives up the color which it had absorbed from the cloth.

The following chemical examination of bran is interesting:—

A pound of bran was boiled at successive times with water; the decoctions, being filtered, let fall in cooling a greyish deposit, which was separated by decantation. The clear liquor

afforded by evaporation to dryness four ounces of a brownish, brittle matter, composed chiefly of mucilage, a little gluten, and starch.

The gray deposit of the above filtered liquor amounted to half an ounce. Nine ounces of the cortical portion of the bran were obtained. The loss amounted to 2½ ounces, being in some measure the hygrometric water of the bran itself.*

BRITISH GUM.—The trivial name given to starch, altered by a slight calcination in an oven, whereby it assumes the appearance and acquires the properties of gum, being soluble in cold water, and forming in that state a paste well adapted to thicken the colors of the calico-printer. (See the articles *Starch* and *Gum*.)

C.

CARBONATES.—Saline compounds in definite proportions of carbonic acid, with alkalies, earths, and the ordinary metallic oxides.

The carbonates principally used in the arts and manufactures are those of *ammonia*, *copper*, *iron*, *lead*, *lime*, *magnesia*, *potash*, *soda*. Native carbonate of copper is the beautiful green mineral called Malachite.

Carbonates are easily analyzed by estimating either by weight or measure the quantity of carbonic acid which they evolve under the decomposing action of somewhat dilute sulphuric, nitric, or muriatic acid; for as they are all compounds of acid, and base in equivalent proportions, the quantity of acid will indicate the quantity of base. Thus, as pure limestone consists of 56 of lime and 44 of acid, in 100 parts, if upon examining a sample of limestone we find it to give out only 22 per cent. of carbonic acid gas, during its slow solution in muriatic acid, we are sure that there are only 28 parts of lime present.

CARBONATE OF AMMONIA.—A salt called in modern chemistry *sesqui-carbonate*, to denote its being composed of one and a half equivalent primes of carbonic acid, and one of ammonia. It consists by Dr. Ure's analysis, of 55·89 carbonic acid, 28·86 ammonia, and 15·25 water, in 100 parts. It is generally prepared by mixing from 1¼ to 1½ parts of well-washed dry chalk, with 1 of sal-ammoniac, introducing the mixture into an earthen or cast-iron retort, or subliming pot, and exposing it to a heat gradually raised to redness. By double decomposition, the ammonia is volatilized in combination with the carbonic acid of the chalk, and the vapors are received in a condensing receiver made either of glass, stone ware, or lead. The chlorine of the sal-ammoniac remains in the

* When boiled with distilled water, goods are cleared pretty well without bran. Certain delicate dyes must be boiled only a few minutes in a strong decoction of bran previously made.—*Ure.*

retort, associated with the basis of the chalk in the state of chloride of calcium. Some ammonia gas escapes during the process.

The saline mass thus sublimed is purified by a second sublimation in glass or salt-glazed earthen vessels. The salt may be obtained, by the above method carefully conducted, in rhomboidal octahedrons, but it is generally made for the market in a compact semi-crystaline white cake. It has a pungent ammoniacal smell; a hot, pungent, alkaline taste; a strong alkaline reaction, and dissolves in two parts of cold water. It must be kept in well-closed vessels, as by exposure to the air a portion of its ammonia exhales, and it passes into the state of the scentless bicarbonate.—(See *Sal Ammoniac.*)

CALCINATION.—The reduction of substances to cinder or ash. The term is derived from the Latin word *calx*, quick-lime, which, as is well known, is prepared by the action of heat upon limestone; and hence the old chemists employed the word *calcination* to express any supposed analogous change, metallic substances being apparently converted into earthy matter by calcination.

CALCIUM.—The metallic base of lime, discovered in 1808 by Davy. This substance has hitherto been obtained in such small quantities, that its properties have not been accurately investigated. It is probably a brilliant white metal, highly inflammable, and more than twice as heavy as water. Combined with oxygen it forms lime, which consists of 20 calcium+8 oxygen=28 lime.—(See *Bleaching*, chapter I., Part II.)

CARBURETS.—In chemistry, the generic term for compounds of carbon with the simple combustibles.

CAUSTIC.—Any chemical substance corrosive of the skin and flesh; as potash, called common caustic, and nitrate of silver, called lunar caustic, by surgeons.

CHALK.—A friable carbonate of lime, white, opaque, soft, dull, or without any appearance of polish in its fracture. Its specific gravity varies from 2·4 to 2·6. It usually contains a little silica, alumina, and oxide of iron. It may be purified by trituration and elutriation. The silicious and ferruginous matters subside first, and the finer chalky particles floating in the supernatant liquid, may be decanted with it, and obtained by subsidence. When thus purified, it is called *whitening* and Spanish white. Pure chalk should dissolve readily in dilute muriatic acid, and the solution should afford no precipitate with water of ammonia.—(See *Steatite.)*

CHEMISTRY.—Chemistry is a department of science, the objects of which are to investigate the nature and properties of the elements of matter, and their mutual actions and combinations; to ascertain the proportions in which they unite, and the modes of separating them when united; and to inquire into the laws and powers which preside over and affect these agencies.

CHLORATES.—Combinations of chloric acid with salifiable bases. Of these salts the *chlorate of potash* is best known. Chlorate of potash consists of 76 chlorine acid+48 potassa=124 of the chlorate.

CHLORIDES.—Combinations of chlorine, corresponding with the oxides. Common salt is a *chloride of sodium;* that is, a binary compound of chlorine and sodium. Where there are two chlorides of the same base, the relative proportions of chlorine in them are almost invariably as 1 to 2; hence the terms *protochloride* and *bichloride*. Calomel and corrosive sublimate are the protochloride and bichloride of mercury. The latter is frequently termed *perchloride*. In calomel 200 of mercury are combined with 36 of chlorine, and in corrosive sublimate with twice 36 or 72.

CHLORIDE OF LIME.—The manufacture of chloride of lime is of great importance, and is carried on upon a large scale. For its preparation, see chapter I., Part II.

CHLORINE.*—This, in a separate state, and under ordinary circumstances, is a greenish-yellow gas; but when submitted to a pressure of four atmospheres, it becomes a yellow transparent liquid. The gas, if breathed undiluted, is fatal to animal life; yet it does not extinguish flame; on the contrary, various bodies, when immersed in it, take fire spontaneously. A candle burns in it with a red flame; and a piece of phosphorus introduced into it burns with a pale white light. Copper, tin, zinc, arsenic, and antimony, when introduced into it in thin leaves, or reduced to filings, take fire, and combining with the gas form compounds analogous to the *oxides*, and which are therefore named *chlorides*. Mercury also enters rapidly into combination with it, forming chloride of mercury; a substance better known as *corrosive sublimate* (which see). Water absorbs twice its bulk of the gas, and the solution is called chlorine-water. If this solution be exposed to the sun's light it is observed to give off oxygen, and after a time it is found that the solution has attained acid properties: that it has lost the astringent taste which it originally possessed, and has attained instead of this and other properties, the particular properties of the acid popularly known as spirit of salt, and which, it is plain from this simple experiment, must consist of chlorine and hydrogen in combination.

One of the most remarkable properties of chlorine is its power of destroying all vegetable colors. If a vegetable blue—for instance the blue infusion of red-cabbage—be exposed to its action, the color is not altered to red, as it would be by an acid, nor to green, as it would be by an alkali, but is totally destroyed; and the medium in which the blue was contained, appears colorless, at least so far as the vegetable was concerned. On this account chlorine has been introduced as a powerful agent in the

* From a Greek word signifying "green" from its color.

art of bleaching. Thus if unbleached linens be properly exposed to its action, the matter which gives them their gray color is decomposed, and the linen assumes the whiteness which is natural to its fibres. However, if applied in its pure state, and not sufficiently diluted, chlorine attacks the vegetable fibre, and invariably destroys the strength and texture of the linen, and therefore it is a dangerous agent in the hands of the inexperienced. To render it more safe and convenient of application, it is always tempered by the quiescent affinity of some alkaline base, as potash, soda, or lime. A weak solution of caustic potash, or soda saturated with the gas, affords a "bleaching liquor," which is still used by some bleachers and calico printers in their more delicate processes; but the price of these alkalies has led to the employment almost universally of the "bleaching powder," manufactured to an immense extent in England and on the continent of Europe, under the name of "chloride of lime."

The bleaching property of chlorine consists in its powerful affinity i hydrogen; not only does it combine rapidly with that element in the ga eous state, under the influence of light, but seizes upon it in many of i liquid and solid combinations—as in volatile oils, which it inflames, an in yellow wax, cotton and flax, which it whitens by decomposing the mat ter which gives them color, and of which hydrogen is reckoned the basis For the same reason, it is used successfully in destroying malaria, and putrescent miasmata, which all contain hydrogenous matter as their base, and which is seized upon by this energetic element. It is the same affinity for hydrogen which causes the evolution of oxygen gas from water which has absorbed chlorine; the chlorine combines with the hydrogen of the water, forming hydrochloric acid, and liberates the oxygen, the other element of the water.

It was stated that the grand source of chlorine is the water of the ocean. This is an enormous solution of *salt*—a universally known and indispensable article of consumption with the human race, an article indeed which seems to be essentially necessary to maintain the body in a healthy condition. Now this *salt* is a compound of chlorine and a metal; it is in fact a chloride, consisting when pure of 60 of chlorine and 40 of sodium in 100 parts; and whether it be obtained by evaporation of sea water, or be dug out of the salt mines of Wieliczka or Northwich, it has the same composition. It is never indeed found unmixed with foreign matters, but it may be separated from all impurities by appliances of chemistry, which is foreign to this part of our subject.

To separate the chlorine from the metallic base with which it is in combination in the salt, it is only necessary to devise a means of subverting the affinity which retains them in union. This can readily be done in the following way:—

Introduce into a glass retort a mixture of three parts of common salt, and two parts of black oxide of manganese, and pour upon the mixture two parts of sulphuric acid diluted with its

own weight of water. (A tubulated retort should be used, and the acid should be added at two or three different times to avoid too violent an effervescence.) The heat of a spirit lamp being applied to the retort, the gas will be expelled, and may be collected in bodies inverted in as little water as will answer the purpose, in order to prevent waste by absorption.

This is a method of obtaining chlorine from common salt; it is that practised by the manufacturer upon an extended scale; but chlorine may be obtained more conveniently in small quantities by *pouring hydrochloric acid upon black oxide of manganese in a retort, and applying a gentle heat as before.* In this case a portion of the acid is decomposed, and the element chlorine passes off in the form of a green pungent gas.—(See *Bleaching*, chapter I., Part II.)

CHROMATE OF LEAD.—(See chapter IV., Part I.)

CHROMATE OF POTASH.—All the salts of chromic acid are of a yellow, orange, or red color: by mixing them with a little alkali, they afford, with the heat of the blowpipe, a beautiful green-colored glass. This green color of the oxide of chrome may also be developed by treating any chromate with muriatic acid and a little alcohol. If we neutralize chromic acid with potash, by evaporation of the solution, we shall obtain two distinct salts. The first which crystalizes will be a bichromate of potash, consisting of 2 equivalents of acid and 1 of base; the second, which is much more soluble, of 1 equivalent of acid and 1 of base. The latter, or *chromate of potash*, is procured in prismatic crystals of a fine lemon-yellow color, and possesses a cool, bitter, disagreeable taste. It turns the yellow color of vegetables red. When exposed to heat it is not decomposed, but assumes a tint of green from the formation of a minute portion of protoxide. Though very soluble in water, it is insoluble in alcohol, and does not contain any water of crystalization.

The *bichromate of potash* (chrome) is much less soluble than the neutral chromate, and 100 parts of water only take up 10 of the salt. It forms beautiful tabular crystals of a rich red color, which are anhydrous, and consist of 2 equivalents of the acid and 1 of the alkali. When exposed to heat they suffer decomposition; the neutral chromate is formed, mixed with oxide of chrome, from the deoxygenation of the excess of acid. The solution of this salt reddens vegetable blue colors. Chromate of potash is manufactured on a large scale by heating to redness, with an equal weight of nitre, a mineral known by the name of chromate of iron, and which is a native compound of the oxides of iron and chrome. Chromic acid is thus generated, which combines with the alkali of the nitre. The mass obtained is digested in water, and the solution neutralized by nitric acid. By evaporation crystals of nitre are separated, and the residual liquid, by spontaneous evaporation, affords small crystals of the salt.

From the chromate of potash all the other chromates are easily obtained by double decomposition: the soluble salts of baryta, lead, protox-

ide of mercury, and silver, afford insoluble chromates of the same bases. The first two are yellow, the second orange-red, and the third deep red. Many of these salts are valuable as brilliant pigments; and a sub-chromate of lead, formed by boiling the neutral chromate with potash, is extensively used as a fine unalterable red in calico-printing.

CHROMATICS.—That part of optics which treats of the colors of light and of natural bodies. This is a very important branch of physical science, and one which of late years has been prosecuted with great assiduity. Until Newton undertook his memorable experiments on the refraction of light, the cause of the different colors of bodies had never received any satisfactory explanation: such, indeed, was the difficulty which the ancients attached to this subject, that Plato considered it to be an usurpation of the rights of the Deity to attempt the investigation of this mystery of nature. The discovery of the difference of refrangibility in the colored rays of the solar spectrum afforded a clue to the solution of the problem; and Newton demonstrated, by a series of decisive experiments, that color depends not on any modification of light acquired by reflection or refraction, but is inherent in the light itself; the solar beam being composed of rays of all the colors contained in the spectrum, which are differently affected in passing through refracting media. This hypothesis of the existence of different species of luminous molecules is founded on the other hypothesis, that light is a substance emitted from the sun or luminous body, and is indeed a necessary consequence of that theory; for if color depended merely on a difference of the masses, or of the initial velocities of the particles, it would follow that the dispersion of the rays, in passing through a prism, would always be proportional to the refraction, which is well known, is contrary to experience.—*Brande.**

CHROMIUM is a whitish, brittle, and very infusible metal; sp. gr. 5·5. When heated with nitre it is converted into *chromic acid*.—(See chapter IV., Part I.)

CINNABAR.—The native red sulphuret of mercury. It occurs sometimes crystalized in rhomboids; has a specific gravity varying from 6·7 to 8·2; a flat conchoidal fracture, is fine grained; opaque; has an adamantine lustre, and a color passing from cochineal to ruby-red. The fibrous and earthy cinnabar has a scarlet hue. It is met with disseminated in smaller or larger lumps in veins, which are surrounded by a black clay, and is associated with native quicksilver, amalgam, with iron-ore, lead-glance, blende, copper-ore, gold, &c. Its principal localities are Almaden in Spain, Idria in the Schiefergebirge, Kremnitz and Schemnitz in Hungary; in Saxony, Bavaria, Bohemia, Nassau, China, Japan, Mexico, Columbia, Peru. It consists of two primes of sulphur, = 32·240, combined with one of mercury, = 202·863; or in 100 parts, of 12·7 sulphur

* See chapter II., Part I.

+ 87·3 mercury. It is the most prolific ore of this metal; and is easily smelted by exposing a mixture of it with iron or lime to a red heat in retorts.* Factitious cinnabar is called in commerce *Vermilion*.—(See *Vermilion*.)

CLAY.—In chemistry, a term generally applied to a variety of *plastic* earthy compounds of different colors, and having much attraction for water. They are essential in the manufacture of pottery, and consist of silica, with variable quantities of alumina, and generally some oxide of iron.—(See *Alum*.)

COLOR; ITS INFLUENCE ON ODORS.—The following interesting series of experiments instituted by Dr. Stark, to ascertain the influence of color upon odors, is well worthy the attention of men of science. In fact the subject has not, that we are aware, hitherto been investigated, and we know of no recorded facts in which the influence of color on odors has been pointed out.

The attention of Dr. Stark was first directed to this subject during his attendance at the anatomical rooms, in the winter session of 1831. During the early part of that winter he generally wore a light olive-colored dress, but happening one day to attend the rooms in black clothes, he was not a little struck by the almost intolerable smell they had acquired. The smell was so very strong as to be remarked even by the family at home, and it was recognised on the same piece of dress for several days. No odor to the same extent had been remarked in the lighter colored clothes. The fetid smell which they more or less acquired in the atmosphere of the rooms was comparatively trifling, and slight exposure to the air alone was necessary to deprive them of the odor which they had thus contracted.

This circumstance led to a series of experiments, to ascertain, if possible, why different clothes of nearly the same texture, but not of the same color, should attract odors in proportions so very different. The result was that the color of bodies, independent of the nature of the substance, modifies in a striking manner the capability of surfaces for imbibing and giving out odors.

1. Black and white wool was enclosed, ten grains of each, in a vessel, with a small piece of camphor, and kept carefully secluded from the light. When examined six hours afterwards, it was at once evident to the sense of smell that the black wool had attracted more of the odorous particles than the white wool, though neither had gained any appreciable weight.

2. Equal weights of black and white wool were enclosed by Dr. Stark, in a small drawer along with a piece of assafœtida; in twenty-

* Nitric acid has not the property of decomposing cinnabar, but nitromuriatic acid dissolves it with rapidity, when assisted by heat.

four hours the black wool had contracted a strong odor of the gum, while in the white wool, the smell was scarcely perceptible.

3. To try the effect of odors upon a vegetable substance, equal quantities of black and white cotton wool were taken, and enclosed with assafœtida. Two similar quantities were at the same time exposed to the emanations of camphor in another drawer. In both, the black-colored cotton had attracted the greatest quantity of odorous particles, as palpably evidenced by the smell.

4. Equal weights of black, red, and white wool, were enclosed in a drawer with assafœtida; and similar quantities of these colored wools in another drawer with camphor. The result was as before. The black in both experiments had attracted by far the greatest quantity of odorous particles, as evidenced to smell; the red next followed in point of intensity of smell, and the white, so far as could be judged, had attracted least of the odor.

5. The same experiments were tried on cotton of similar colors, and with the same results.

6. Six different colored wools, enclosed, an equal weight of each, viz., black, blue, green, red, yellow, and white, with assafœtida. They were ranged circularly round the odorous body, without touching it or one another, and were then covered over and excluded from the light. At the end of twenty-four hours they were examined. The black was found to have much the strongest smell of assafœtida; the blue the next; after that the red, and then the green, the yellow had but little smell, and the white scarcely any.

7. A similar experiment, using camphor instead of assafœtida, afforded precisely the same results.

8. Various colored cottons were treated in the same manner. In all these the smell was invariably found to be of corresponding intensity, according to the color, as in the wools.

9. Silks of different colors gave the same results.

10. Dr. Stark next endeavored to ascertain the comparative power of vegetable and animal substances, so far as regards their influence over odors. This was a much more delicate point to ascertain with sufficient accuracy, and free from fallacy, as it was difficult to obtain wool of the same degree of fineness as cotton, the substances he generally preferred for these experiments. Equal weights of black and white wool were first enclosed, and black and white cotton, with camphor. After twenty-four hours, the black wool had acquired a stronger smell than the cotton of similar color; the white wool had also taken up more of the odorous particles than the white cotton, though the odor in both was very feeble.

11. When assafœtida was used in a similar experiment, the odor was much more distinguishable, and it could at once be distinguished by smell, that the wool had taken up much more of the odor than the cotton. In-

deed, from many experiments made to ascertain this fact, wool appears to have a peculiar attraction for fetid odors. For instance, if, after having allowed wool to lie in contact with camphor for some time, it be afterwards placed, even for a very few hours, near a minute portion of sulphuret of barium (which, it is well known, exhales copiously the fetid odor of sulphuretted hydrogen), it quickly loses the camphorous smell, and acquires and even retains in considerable intensity, the fetid smell of the sulphuret. It is proper to mention, that in most of these experiments, Dr. Stark did not trust to his own olfactory organs alone. All the members of his family, and several of his friends, having lent their aid to distinguish between the different intensities of the odor which each substance had attracted; and though only a few experiments are here detailed, similar ones have been many times performed by the same gentleman, with various other odorous substances. The whole of these in their general results seemed to establish the fact, that the color of substances exerted a peculiar influence over the absorption of odors.

In all these experiments, however, reliance had to be placed upon one sense alone, viz. that of smell, as none of the substances employed had gained any appreciable weight. It was therefore, desirous, that, if possible, at least one experiment should be devised, which would shew, by the evidence of actual increase of weight, that one color invariably attracted more of any odorous substance than another; and upon considering the various odorous substances which could be easily volatilized without change, and whose odor was inseparable from the substance, camphor was fixed upon as the one best suited to the purpose. In an experiment of this nature it was necessary that the camphor should be volatilized, or converted into vapor, and that the colored substances should be so placed as to come in contact with the camphor while in that state. It was therefore of the first importance to prevent currents of air within the vessel in which the experiment was conducted, and with this view, a funnel-shaped vessel of tin plate, open at the top and bottom, was used. This rested on a plate of sheet iron, in the centre of which the camphor to be volatilized was placed. The colored substances, after being accurately weighed, were supported on a bent wire, and introduced through the upper aperture. This was then covered over with a plate of glass. Heat was now applied gently to volatilize the camphor; and when the heat was withdrawn and the apparatus cool, the colored substances were again accurately weighed, and the difference in weight noted down.

Proceeding on this plan, the most satisfactory and conclusive results were obtained. The deposition of the camphor in various proportions on the colored substances submitted to experiment, offered evidence of the particular attraction of colors for odors, resting on ocular demonstration; and when to this is added the evidence arising from a positive increase of weight, as ascertained by the balance, the conclusions previous-

ly drawn from the sense of smell are confirmed in a singular and very satisfactory manner. In this mode all the former experiments, with differently colored substances, were repeated; but we shall here only detail a few, as sufficient to shew the general results.

1. Ten grains of white, and the same quantity of black wool were taken, suspending them in the manner stated; the camphor was vaporized. When the apparatus cooled, it was found, on weighing the wool, that the white had gained $1\frac{8}{10}$ grain in weight, and the black $1\frac{8}{10}$ grain.

2. In a similar experiment, but using three colors of wool, white, red, and black, it was ascertained that the white wool had gained $\frac{3}{10}$ths of a grain; the red $\frac{8}{10}$ths; and the black $1\frac{4}{10}$ths grain.

3. In another, where the heat was applied for about ten seconds, the white had gained no appreciable weight, and but little smell; the red had gained $\frac{1}{20}$ of a grain; while the black had acquired $\frac{3}{10}$ths of a grain.

4. In an experiment with black, red, green, and white wool, the results were—

Black gained	$\frac{3}{10}$ grain
Red	$\frac{2}{10}$
Green	$\frac{25}{10}$
White	$\frac{1}{10}$

5. In an experiment with wools of nearly the same fineness, colored black, blue, red, green, and white, ten grains of each, exposed to the vapor of camphor, give the following results:—

Black gained	$1\frac{2}{10}$ grain
Dark blue	$1\frac{2}{10}$
Scarlet red	1
Dark green	1
White	$\frac{7}{10}$

In repeating this experiment the dark green was $\frac{7}{10}$, while the red was only $\frac{6}{10}$; the others in the order as before.

The experiment was now varied, by employing square pieces of card of equal size, colored with different preparations of lead. This was done with the view of ascertaining whether smooth surfaces of equal density, and colored nearly as possible with matter of the same nature, would absorb odorous particles with the same facility as loose portions of wool. The colors were mixed up with a solution of gum arabic, and laid on the cards as equally as possible with a camel-hair pencil.

6. Pieces of card of equal size being colored as mentioned, with various preparations of lead, namely, red, brown, yellow, and white, and previously weighed, were exposed to the vapor of camphor in the vessel before described. After exposure for some time, and when cool, it appeared on weighing that the

Red had gained	1 grain
Brown	$\frac{9}{10}$
Yellow	$\frac{6}{10}$
White	a trace

The whole of the upper surfaces of the red and brown cards were thickly covered with a fine light downy deposit of camphor. The white card had an extremely fine deposit on its surface, but inappreciable by the balance, which turns with the fiftieth part of a grain.

7. Another experiment with cards, colored black, red, brown, yellow, and white, exposed to the vapor of camphor, gave the following results:—

Black gained	1 grain.
Red	$\frac{9}{10}$
Brown	$\frac{7}{10}$
Yellow	$\frac{5}{10}$
White	$\frac{4}{10}$

8. In a similar experiment with cards colored black, dark blue, dark brown, orange red, and white, the attractive powers were as follows:—

Black gained	$\frac{9}{10}$ grain
Dark blue	$\frac{8}{10}$
Dark brown	$\frac{4}{10}$
Orange red	$\frac{3}{10}$
White	$\frac{1}{10}$

In all these experiments it was invariably found that the black attracted most, the blue next; then followed the red and green; and after these the yellow and white. The heat was never continued so long as to warm the apparatus, else the whole camphor would have been driven off. Neither was such a quantity of camphor used as would have given a thick coating to the wool employed, as then the attraction of the colored surfaces might have been diminished.

1. The next set of experiments were intended to ascertain the comparative attraction of animal and vegetable substances. The first of these was upon equal weights of black wool and black silk, (ten grains,) exposed to the vapor of camphor in the manner already stated. The black wool gained $1\frac{5}{10}$ grain, and the black silk $1\frac{7}{10}$ grain. From this experiment it would appear that of these two animal substances, silk possesses the greatest attraction for odors.

2. In equal weights of white wool and white cotton, the cotton had gained $\frac{3}{10}$ths of a grain, and the wool $\frac{4}{10}$ths.

3. In another experiment with white silk, white wool, and white cotton, ten grains of each, the result was:—

Silk had gained	$3\frac{8}{10}$ grains
Wool	$2\frac{4}{10}$
Cotton	$2\frac{2}{10}$

4. In a similar experiment with the usual weight of the same articles,

Silk had gained	$1\frac{4}{10}$ grain
Wool	$\frac{5}{10}$
Cotton	$\frac{4}{10}$

5. Another experiment, in which black silk, black wool, and black cotton, were exposed, in equal quantities of the usual weight, to the vapor of camphor, as before described, gave this result:—

Black silk had gained . .	$\frac{2}{10}$ grain
Black wool	$\frac{1}{10}$
Black cotton	$\frac{1}{20}$

6. An experiment with white silk, white wool, white cotton, and white card, each weighing ten grains, and exposed as before, gave the following results:—

White silk had gained . .	$1\frac{9}{10}$ grain
White wool	$1\frac{1}{10}$
White cotton	1
White card	$\frac{4}{10}$

The last experiments tend to show that different substances attract odors in different proportions, and this independent of the texture or fineness of the substance employed. Wool, though generally coarser in the filament than cotton, has yet a greater attraction for odors; and silk more than wool. The general conclusion would appear to be *that animal substances have a greater attraction for odors than vegetable matters; and that all these have their power much increased by their greater darkness or intensity of color.* These experiments seem also to establish, *that the absorption of odors by colored substances is regulated by the same law which governs the absorption of light and heat.* The analogy goes still further; for in other experiments made with a view to ascertain this point, it was invariably found *that the power of color in radiating or giving out odors, was in strict relation to the radiation of heat in similar circumstances.* Dr. Stark's first experiments on this branch were with differently colored wools, enclosed for a certain time in a drawer along with assafœtida and camphor, and afterwards exposed for a specific period to the action of the air. Though one can easily judge by the sense of smell alone the different intensities which these articles have acquired immediately on being taken out of the drawer, yet, after exposure for some time to the air, the difference of intensity is much more difficult to be

perceived. In general, it appeared that the whole of the substances lost their sensible odor in nearly the same space of time, though the odorous particles given out by the black were of course much greater in quantity than the others.

To demonstrate this, pieces of card, colored as before, black, dark blue, brown, orange, red, and white, were taken, and after having exposed them to the vapor of camphor, in the usual manner, they were taken out of the vessel, weighed, and left in the apartment for twenty-four hours. Upon carefully re-weighing the cards at the end of this period, it was found that the black had lost one grain; the blue nearly as much; the brown $\frac{9}{10}$ths of a grain; the red $\frac{8}{10}$ths; and the white $\frac{5}{10}$ths of a grain. In about six hours after this the black and blue had completely lost their camphor; the brown and red had the merest trace, inappreciable to a delicate balance, while the white still retained about $\frac{1}{30}$th of a grain.

In another experiment with cards, colored dark blue, dark brown, orange red, yellow, and white, they had gained in weight, after exposure to the vapor of camphor,

Dark blue	$\frac{9}{10}$ grain
Dark brown	$\frac{3}{10}$
Orange red	$\frac{6}{10}$
Yellow	$\frac{5}{10}$
White	$\frac{4}{10}$

After lying in the apartment for twenty-four hours, the cards were again carefully weighed, when the camphor remaining was found to be on the

Dark blue	$\frac{1}{30}$ grain
Dark brown	$\frac{1}{10}$
Orange red	$\frac{2}{10}$
Yellow	$\frac{1}{10}$
White	$\frac{3}{10}$

Hence in the same space of time the loss in each was,

Dark blue	$\frac{26}{30}$ grain
Dark brown	$\frac{21}{30}$
Orange red	$\frac{12}{30}$
Yellow	$\frac{12}{30}$
White	$\frac{3}{30}$

If it be thus certain that odorous emanations have not only a particular affinity for different substances, but that the color of those substances materially affects their absorbing or radiating quality, the knowledge of these facts may afford useful hints for the preservation of the general

health during the prevalence of contagious or epidemic diseases.—(See conclusion of chapter II., Part I.)

COMBINATION.—A chemical term which denotes the intimate union of dissimilar particles of matter, into a homogeneous-looking compound, possessed of properties generally different from those of the separate constituents.

COMBUSTIBLE; any substance which exposed in the air to a certain temperature, consumes spontaneously with the emission of heat and light. All such combustibles as are cheap enough for common use go under the name of fuel. Every combustible requires a peculiar pitch of temperature to be kindled, called its *accendible* point. Thus phosphorus, sulphur, hydrogen, carburetted hydrogen, and carbon, each take fire at successively higher heats.

COMBUSTION results in common cases from the mutual chemical reaction of the combustible, and the oxygen of the atmosphere, whereby a new compound is formed; the heat and light evolved being most probably produced by the rapid motions of the particles during the progress of this combination.

COPPERAS (sulphate of iron).—Copperas or sulphate of iron, is a crystaline compound of sulphuric acid and protoxide of iron; hence called, by chemists, the proto-sulphate; consisting of, 26·10 of base, 29·90 of acid, and 44·00 of water in 100 parts; or of 1 prime equivalent of protoxide, 36, + 1 of acid, 40, + 7 of water, 63, = 139. It may be prepared by dissolving iron to saturation in dilute sulphuric acid, evaporating the solution till a pellicle forms upon its surface, and setting it aside to crystalize. The copperas of commerce is made in a much cheaper way, by stratifying the pyrites found in the coal measures, upon a sloping puddled platform of stone, leaving the sulphuret exposed to the weather, till, by the absorption of ogygen, it effloresces, lixiviating with water the supersulphate of iron thus formed, saturating the excess of acid with plates of old iron, then evaporating and crystalizing. The other pyrites, which occurs often crystalized, must be deprived of a part of its sulphur by calcination, before it acquires the property of absorbing oxygen from the atmosphere, and thereby passing from a bisulphuret into a bisulphate. Alum schist very commonly contains vitriolkies, and affords, after being roasted and weather-worn, a considerable quantity of copperas, which must be carefully separated by crystalization from the alum.

Copperas forms sea-green, transparent, rhomboidal prisms, which are without smell, but have an astringent, acerb, inky taste; they speedily become yellowish-brown in the air, by peroxidizement of the iron, and effloresce in a warm atmosphere: they dissolve in 1·43 parts of water at 60°, in 0·27 at 190°, and in their own water of crystalization at a higher heat. This salt is extensively used in dyeing black, especially hats, in making ink and Prussian blue, for reducing indigo in the blue vat, in the

China blue dye, for making the German oil of vitriol, and in many chemical and medicinal preparations.

CORROSIVE SUBLIMATE.—The bichloride of mercury, composed of 200 mercury + 72 chlorine. It is an acrid poison of great virulence: the stomach pump and emetics are the surest preventives of its deleterious effects when accidentally swallowed; white of egg has also been found serviceable in allaying its poisonous influence upon the stomach. Its specific gravity is 52. It requires 20 parts of cold water, but only 2 of boiling water, for its solution. It is used in calico-printing.—(See *Chlorine;* also *Calico-Printing.*)

CRYSTALIZATION.—The forms which matter assumes when it enters into the crystaline state are very various. Even the same particles do not invariably take the same mathematical figure under the influence of the molecular force of cohesion. The laws which regulate their aggregation, are continually liable to disturbance from extraneous causes. Among these, the nature of the medium in which crystalization takes place, and the temperature under which the crystal is formed, are perhaps the most easily recognised. Thus, crystals of the same salt formed in a hot and cold solution, under atmospheric pressure, or in a vacuum, are often different in their geometrical characters; and the forms assumed by the same body, when crystalized from fusion and from solution, are very rarely identical. In cases where two distinct geometrical forms of crystals are thus obtained, the body is said to be dimorphous; but if we examine very closely the various form of crystals of the same substance which we obtain from a solution, or of the same mineral which we obtain naturally crystalized, we have little difficulty in discovering that the dissimilarity is confined to the mere external appearance, and that internally the structure is uniform. Thus, a crop of crystals of alum exhibit many different forms; but if we examine two of the most dissimilar, by dividing with a knife in the direction of their planes of cleavage —which are readily found by trial—we invariably find them reducible to some primary form—the geometrical solid, termed the octahedron. In nature we similarly meet with numerous crystaline forms of carbonate of lime—not less than six hundred; but actual dissection informs us that they are all resolvable into that form called the rhombohedron. It is thus that, notwithstanding the immense variety of forms which crystals assume, they are all reducible to a few classes, and brought within the cognisance of fixed mathematical laws. By dissection, we readily learn that the atoms forming the crystals are built around a certain nucleus, forming layers over its external faces, and determining the ultimate character of the crystal by the degree of regularity maintained during their deposition. But it may further be observed that this central nucleus itself must be a compound structure, built, like the fully developed crystal, around a central atom, and it is not too much to suppose, although exper-

iment does not guide us so far, that the primary form must be regulated by certain points of attraction and repulsion, which determine the law of molecular cohesion in that species of matter of which the crystal is composed.

This atomic polarity is, indeed, one of the first considerations which occur to the mind in studying the phenomena of crystalization. That it really does exist is at once plain from the simple dissection of a crystal. Did the particles attract each other on all sides equally, there could be no planes of cleavage in a crystal—in other words, the crystal might be divided in one direction as easily and as readily as in another. In fact, there could be no determinate form of crystaline arrangement. The atoms aggregating themselves together under the cohesive force would assume no definite structure, and no other geometrical form than that of a sphere modified by the force of gravity.

It is this atomic polarity which has given rise to the plausible hypothesis, that crystalization is referable to the same law which determines the position of the mariner's needle, when fairly poised. Could we form, with the same accuracy as nature, a great number of particles of steel—all of definite and regular forms, and all equally magnetized; and, farther, could we suspend them in a fluid of exactly their own specific gravity, we might reasonably expect to realize some example of the crystalizing process. We would have the particles adhering together by their opposite poles, and disposed in layers around a central particle, which, having only two poles, would give to the crystal the form of a square prism, which might be divided into cubes by sections across its length. Our crystal would be, of course, but a rude imitation of nature's work, since the finest particle we could form would be itself an aggregate of many of those atoms which go to the composition of a sensible molecule.

That there is a fundamental difference in the laws of molecular cohesion, concerned in the formation of a crystal, is proved by evidence derived from a variety of sources. The peculiar and well-known action which many crystaline bodies exert upon light, furnishes, perhaps, the most direct and extraordinary information of this fact; it is, indeed, to this physical difference of constitution in crystaline bodies that we owe the great increase which has of late been made to our knowledge of the more recondite properties of light.

The opinion entertained with respect to the electric, galvanic, and magnetic forces, is, that they depend on the same ultimate cause, and are, in fact, only modified exhibitions, like light and heat, of one and the same agency. We also know from experiment that a change of temperature—the contact of bodies with each other—rapid and slow cooling—and the application of heat and light—all tend as disturbing causes to change the electric state of bodies. An analogous series of changes is

exemplified during the phenomena of crystalization, when the material particles are similarly exposed to extraneous influence. Thus, the yellow binoxide of mercury, when touched, begins instantly to crystalize, a creeping motion being perceptible in it during the process; at the same time its color changes to deep scarlet. The often repeated experiment of the crystalization of a quantity of glauber salt which had been poured, while hot, into a stoppered flask, and allowed to cool *in vacuo*, is a similar illustration of the disturbing influence of the atmosphere. The disturbing influence of light is equally remarkable, and is well illustrated by the crystalization of camphor, from its solution when exposed in a glass vessel to the strong light of the sun.

In referring to the analogy which is thus observed to exist between the development of electricity and of crystalization, it is interesting, as affording another link to the series of analogies, to remark the peculiar connexion between the vibration of certain bodies and the formation of crystaline structure. For example, we have no more common experiment than the formation of regular geometrical figures *by sand spread upon a plate of glass, when the bow of a violin is drawn across the edge of the glass.* Whether this be merely a coincident case, or a fact induced by the same cause which determines the symmetrical arrangement of the particles of matter in crystaline structure, we do not pretend to decide; still, we think that it is not to be overlooked, as it may yet enable us to advance a step towards a physical explanation of the laws which govern the aggregation of those atomic elements, by which material bodies are built up.

The galvanic experiments of Mr. Crosse have likewise their interest, and throw considerable light upon the relation which exists between galvanic action and the formation of crystaline structure. These experiments go to show that one species of crystal may be formed in solutions of the salt at the positive pole of the battery, and a different species of crystal at the negative pole. Thus, in a solution of bicarbonate of lime, he obtained at the negative pole the rhombohedral crystal, whereas, at the positive pole, he obtained prismatic crystals of arragonite. Some of these celebrated experiments were as follows:—

"In a cavern, of which the vault is covered with fine crystals of arragonite and carbonate of lime, the water which drops from the vault holds in solution 10 grains of the carbonate, or rather bicarbonate of lime, with a little sulphate of the same to each pint. A glass of this water was submitted to the action of a powerful battery, and in a few days there was found at the negative pole rhombohedral crystals of the carbonate of lime. Another experiment was by letting the water drop on a piece of brick, subjected to a current from 100 five-inch plates, the brick being supported by a funnel, which conducted the water into a vessel below. After a few months the brick near the negative pole of the

battery was covered with crystals of carbonate of lime, and near the positive were formed crystals of arragonite. The same experiment being repeated with fluosilicic acid, regular hexahedral pyramids, similar in all respects, were obtained."

These experiments throw a flood of light on the nature of the power which operates on the particles of matter during the crystaline process,—the electric current of galvanic action forming crystals and disposing them according to their positive and negative qualities. From numerous facts, it would appear that the crystaline arrangement is produced by electrical attraction and repulsion. The various changes of circumstances produce among bodies an electrical change, so we observe the same circumstances produce a change in the crystaline form. Bodies mechanically mixed with each other in the first instance, will subsequently assume a crystaline form, and here it would seem that induction had taken place, the particles becoming polarized. In all the processes of crystalization a nucleus is formed, which draws the surrounding particles successively to it. This nucleus, which is often different from the external form of the crystal, being in a certain electrical state, in conformity to the laws of electrical attraction and repulsion, discriminately draws the other particles to it, consequently the formation of the aggregate crystal. And as the electrical state of the first formed nucleus, or the nucleus put in to hasten the process, is determined by its elementary constituents, and the nature of formation; hence the uniformity among bodies in their crystalized form under one circumstance, and the dissimilarity under the other, and why a nucleus of the same substance is the best excitant.—(See *Water of Crystalization.*)

CYANATES; saline compounds of cyanic acid with the bases potash, soda, ammonia, baryta, &c. The first is prepared by calcining, at a dull red heat, a mixture of ferrocyanide of potassium (prussiate of potash) and black oxide of manganese.

CYANIDES; compounds of cyanogen with the metals; as cyanide of potassium, sodium, barium, calcium, iron, mercury. The last is the only one of importance in a manufacturing point of view, since from it prussic acid is made.

CYANIDE, FERRO.—Double compound of cyanogen with iron, and of cyanogen with another metal, such as potassium, sodium, barium, &c. The ordinary yellow prussiate of potash has this constitution, and is called the ferro-cyanide.

CYANOGEN.—A gaseous compound of two prime equivalents of charcoal = 12, and one of azote = 14 = 26; hydrogen being the radix, or 1. It consists of two volumes of vapour of carbon, and one volume of azote, condensed into one volume; and has therefore a density equal to the sum of the weights of these three gaseous volumes = 1·815. Cyanogen is readily procured by exposing the cyanide of mercury to a dull

red heat in a retort; the gas is evolved and may be collected over mercury. Its smell is very sharp and penetrating; it perceptibly reddens tincture of litmus: it is condensable by pressure at a low temperature into a liquid; and by a still greater degree of cold, it is solidified. When a lighted taper is applied to a mixture of cyanogen and oxygen, an explosion takes place; carbonic acid is formed, and the azote is set at liberty.*

CYANURET OF IRON.—This is obtained by passing an excess of chlorine through a solution of cyanoferride of potassium, allowing the liquid to repose, or, which is better, to heat it to ebullition. A light, green, insipid powder is deposited, mixed with oxide of iron and Prussian blue. Treated with eight or ten times its weight of boiling hydrochloric acid, which destroys the Prussian blue, and dissolves the oxide of iron,—washed and dried in a vacuum, it constitutes the new cyanuret.

D.

DECANTATION.—The pouring off a clear liquid from its subsidence or residue; it is often resorted to in the chemical laboratory instead of filtration, the clear supernatant liquor being poured or syphoned off from precipitates, which may thus be repeatedly washed or edulcorated, so as to free them from all soluble matters.

DECOCTION.—The act of boiling a liquid along with some organic substance, or the liquid compound resulting from that act.

DECREPITATION is the crackling noise, attended with the flying asunder of their parts, made by several salts and minerals, when heated. It is caused by the unequal sudden expansion of their substance by the heat. Sulphate of baryta, chloride of sodium, calcareous spar, nitrate of baryta, and many more bodies which contain no water, decrepitate most violently, separating at the natural joints of their crystaline structure.†

DELIQUESCENT is said of a solid which attracts so much moisture from the air as to become spontaneously soft or liquid; such as potash and muriate of lime.

DEUTOXIDE literally means the *second oxide*, but is usually employed to denote a compound containing two atoms or two prime equivalents of oxygen to one or more of a metal. Thus we say deutoxide of copper, and deutoxide of mercury. Berzelius has abbreviated this expression by adopting the principles of the French nomenclature of 1787;

* For a connected view of the various compounds of cyanogen employed in the arts, see chapter V., Part III.

† Some chemists have preposterously enough ascribed the phenomenon to the expansion of the combined water into steam. What a specimen of inductive philosophy!

according to which the higher stage of oxidizement is characterised by the termination *ic*, and the lower by *ous*, and he writes accordingly cupric and mercuric, to designate the deutoxides of these two metals: cuprous and mercurous to designate their protoxides.

E.

EBULLITION.—The following table exhibits the boiling heats, by Fahrenheit's scale, of the most important liquids:—

Ether, specific gravity 0·7365 at 48°		100°
Carburet of sulphur		113
Alcohol, sp. grav. 0·813	Ure	173·5
Nitric acid, 1·500	Dalton	210
Water		212
Saturated solution of Glauber salt	Biot	213¼
do. do. Acetate of lead	do.	215¾
do. do. Sea salt	do.	224¼
do. do. Muriate of lime	Ure	285
do. do. do. 1 + water 2,	do.	230
do. do. do. 35·5 + do. 64·5	do.	235
do. do. do. 40·5 + do. 59·5	do.	240
Muriatic Acid, sp. gr. 1·094	Dalton	232
do. do. 1·127	do.	222
Nitric acid, do. 1·420	do.	248
do. do. 1·30	do.	236
Rectified petroleum	Ure	306
Oil of turpentine	do.	316
Sulphuric acid, sp. gr. 1·848	Dalton	600
do. do. 1·810	do.	473
do. do. 1·780	do.	435
do. do. 1·700	do.	374
do. do. 1·650	do.	350
do. do. 1·520	do.	290
do. do. 1·408	do.	260
do. do. 1·300 +	do.	240
Phosphorus	do.	554
Sulphur	do.	570
Linseed oil	do.	640
Mercury	Dulong	662
do.	Crighton	656
Saturated solution of acet. of soda, containing 60 per cent.	Griffiths	256
do. Nitrate of soda, 60	do.	246

Saturated solution of	Rochelle salt,	containing 90 per cent.	Griffiths	240
do.	Nitre,	74	do.	238
do.	Muriate of ammonia,	50	do.	236
do.	Tartrate of potash,	68	do.	234
do.	Muriate of soda,	30	do.	224
do.	Sulphate of magnesia,	57·5	do.	222
do.	Borax,	52·5	do.	222
do.	Phosphate of soda,	?	do.	222
do.	Carbonate of soda,	?	do.	220
do.	Alum,	52	do.	220
do.	Chlorate of potash,	40	do.	218
do.	Sulphate of copper,	45	do.	216

EFFERVESCENCE.—When gaseous matter is suddenly extricated with a hissing sound during a chemical mixture, or by the application of a chemical solvent to a solid, the phenomenon, from its resemblance to that of simmering or boiling water, is called effervescence. The most familiar example is afforded in the solution of sodaic powders; in which the carbonic acid gas of sesqui-carbonate of soda is extricated by the action of citric or tartaric acid.

EFFLORESCENCE is the spontaneous conversion of a solid, usually crystaline, into a powder, in consequence either of the abstraction of the combined water by the air, as happens to the crystals of sulphate and carbonate of soda; or by the absorption of oxygen and the formation of a saline compound, as in the case of alum schist, and iron pyrites. Saltpetre appears as an efflorescence upon the ground and walls in many situations.

ELECTIVE AFFINITY denotes the order of preference, so to speak, in which the several chemical substances *choose* to combine; or really, the gradation of attractive force infused by Almighty Wisdom among the different objects of nature, which determines perfect uniformity and identity in their compounds amidst indefinite variety of combination.—(See *Affinity*.)

ESSENTIAL OILS, or VOLATILE OILS.—Under this term are included all those peculiar compounds obtained by distilling vegetable substances with water, and which pass over along with the steam, and are afterwards condensed in the liquid or solid form. They appear to constitute the *odorous* principles of vegetables. Their specific gravity fluctuates on either side of that of water; they are very sparingly soluble in water, and these solutions constitute the *medicated waters*; rose, peppermint, and other waters being such solutions of the respective essential oils. They dissolve in alcohol and form *essences*, many of which are used as perfumes. When these oils are pure, they evaporate from paper when held before the fire; but if adulterated with fixed oils, they leave

a greasy stain, and seldom dissolve perfectly in alcohol. The more expensive of these oils are frequently adulterated with the cheaper ones, and this fraud can only be detected by an experienced nose.

EQUIVALENTS, CHEMICAL.—A term introduced into chemistry by Dr. Wollaston to express the system of definite ratios in which substances reciprocally combine, referred to a common standard of unity.—(See *Atomic Theory.*)

EVAPORATION.—The conversion of substances into vapor is one of the most important and general effects of heat. During this process, a considerable quantity of sensible heat passes into the *latent* or insensible state. When a vessel of water is placed upon the fire, its temperature gradually rises till it attains 212°; then, although it remains upon the fire, and of course receives heat as before, it does not become hotter, but is gradually converted into steam or vapor: so that the effect of heat is not to elevate temperature, but to change state or form: that is, in the case of water, to convert it into steam. Hence we assume that steam, though not hotter than water, contains a much larger quantity of heat, and this heat again makes its appearance when the steam is condensed or re-converted into water. At whatever temperature vapor is produced, it is similarly constituted; and that which escapes from water at ordinary temperatures, by the process usually called *spontaneous evaporation*, resembles the former in all respects: hence it is that evaporation is to surrounding bodies a cooling process; and that in the converse change, or the return of the vapor to the liquid state, heat is evolved and rendered sensible. The same general phenomena are observed with all other liquids, and those which evaporate rapidly at common temperatures often give rise to the production of a great degree of cold; such as spirit of wine, or ether. If the latter fluid be suffered to dribble over the bulb of a thermometer, it will cause it to sink below the freezing point of water; and by accelerating similar cases of evaporation, we obtain most intense degrees of artificial cold.

EXPERIMENTS AND OBSERVATIONS ON LIGHT.—The following observations on Light which has "permeated colored Media, and on the Chemical Action of the Solar Spectrum," will interest the reader; especially when taken in connection with chapter II., Part I., and the various observations, throughout this work, touching upon the same subject. From these observations, the dyer as well as the calico-printer, may derive hints which may prove, eventually, of the utmost importance, and it is with this view that we introduce an article of this nature here, although it would not have been altogether applicable in the body of the work, where we have rejected everything (as far as possible) not having a direct bearing, in a practical point of view, upon the subject.

M. Gay Lussac, when speaking of the beautiful discovery of M. Da-

guerre, said "the palette of the painter is not very rich in color; black and white compose the whole. The image, in its natural and varied colors, may remain long, perhaps forever, a thing hidden from human sagacity."*

However, the production of a colored picture of the spectrum by Sir John Herschel, and some effects produced by Mr. Talbot, together with some delicate tinting, led Mr. Robert Hunt, an ingenious artist, of Devonport, to think that colored photographs would come within the range of probability, and from this idea he was induced to pursue a train of experiments, from which, although little has resulted to heighten his first hopes, yet, he gathered much that is curious, and certainly instructive, as some of the following experiments will show:—

Photographic papers.

1. By saturating paper with different chlorides and muriates, always keeping in view the definite proportion required for the quantity of nitrate of silver used; it will be found that almost every variety of shade, from a rich dark purple to a full red, and a few other tints, may be produced at pleasure.

2. The effects of light, passing through colored glasses on various papers, are singularly diversified. The following are a few of the most striking results. (The glasses are, a deep cobalt blue, a full laurel green, an amber yellow, and a rich orange red. They are so framed that all the papers can be exposed at the same time to the solar influence.)

Colors of Glass.

Salt used.	BLUE.	GREEN.	YELLOW.	RED.
	Effects produced.			
a. Chlor. of sodium.	Purple.	Blue.	Violet.	Chocolate.
b. Chlor. of potassa.	Light purple.	Sky blue.	Lt. violet.	Tinted red.
c. Muriate of lime.	Rich violet.	Faint blue.	Blue.	Reddish.
d. Muriate of iron.	Red.	Colorless.	Faint red.	Leaden hue.
e. Muriate of peroxide of iron.	Blue.	Yellowish.	Straw color.	Yel. brown.
f. Mur. of baryta.	Purple red.	Lilac.	Chocolate.	Pink.
g. Muriate of manganese.	Rich brown.	Reddish.	Rose hue.	Yellow.
h. Mur. of ammonia.	Olive brown.	Pale brown.	Brown.	Dull orange.

3. Mr. Hunt found but a modified action from the interference of colored fluids. In a few instances, under a solution of carmine in ammonia, he obtained *the richest crimson dye;* but, as yet, has not been able, by any means which he has used, to fix the color on paper.

4. A paper prepared, by first washing it with a solution of twelve

* The History and Practice of Photographic Drawing, &c., by L. J. M. Daguerre.

grains of iodide of potassium in an ounce of water, and then with a solution of ten grains of the crystalized nitrate of silver in the same quantity of fluid, is very sensitive. When exposed beneath a solution of the ammonia-sulphate of copper to sunshine, it changes to a rich *light-blue*. Acetate of copper produces a *brown*. Muriate of the peroxide of iron imparts a *green tinge*, and solution of carmine a *brown red*.

5. The paper *f*, becomes *red*, when acted on by rays passing through nitrous acid gas, and is tinged *yellow*, by the light which has been subjected to the interference of chlorine and its protoxide.

6. To have as full a volume as possible of iodine and bromine vapor, carefully closed vessels, containing a small portion of these bodies, were placed upon a plate of copper warmed by water.

The paper, *h*, was laid beneath them and exposed to luminous influence. Under the bromine it was unchanged, but beneath the iodine the paper became richly iridescent. The colors changed to a uniform velvet tint upon a few minutes exposure to direct sunshine.

7. Papers already darkened by sunlight during prolonged exposure to the influence of the dissevered rays of the spectrum, assume a variety of colors. The same changes may be effected by carefully arranging glasses, and placing the photographic preparations beneath them. We shall copy exactly the memoranda of Mr. Hunt's journal.

Dec. 12, 1839.—He placed under blue, green, yellow, and red glass, the following papers:—

A. *Muriate of ammonia*, with two washings of solution of the nitrate of silver, darkened by exposure to a rich chocolate.

B. *Muriate of manganese*.—Silver, two washings, darkened to a full brown.

C. *Iodide of potassium*.—Silver, one washing, darkened to a yellow brown.

D. *Iodide of potassium* and silver, two washings, darkened to a red brown.

E. *Chloroidic acid*.—Silver, two washings, darkened to a rich bronze.

F. *Chloroidic acid with Liquor potass*.—Silver, two washings, darkened to a blue brown.

Dec. 13.—After twelve hours exposure to the dull light of rainy weather, the paper, E, became blue under the blue glass. No change was apparent on the others.

Dec. 27. *Colors of Glass.*

		Blue.	*Green.*	*Yellow.*	*Red.*
A.	became	Olive.	Deep green.	Dirty yellow.	Red.
B.	do.	Deep brown.	Bat color.	Blue brown.	Red.
C.	do.	do.	Darkened.	No change.	Red brown.
D.	do.	Black.	Light brown.	Rich brown.	Brick red.

		Blue.	*Green.*	*Yellow.*	*Red.*
E.	became	Blue black.	Darkened.	Darkened.	Dusky red.
F.	do.	Black brown.	Dull plum.	Bluish.	Reddened.

Jan. 2, 1840.—All the papers went on increasing the distinctness of their colors, except E, and F, which assumed different shades of blackness.

(E *and* F *were removed, and a paper,* G, *prepared with muriate of baryta and two washings of silver, darkened to a chocolate, substituted.*)

Feb. 7. *Colors of Glass.*

		Blue.	*Green.*	*Yellow.*	*Red.*
A.	became	Rich olive.	Green.	Yellow.	Purple.
B.	do.	Black.	Chocolate.	Light brown.	Red.
C.	do.	do.	Red brown.	do.	Brown.
D.	do.	Chocolate.	Umber brown.	Black.	Red brown.
G.	do.	Bright olive.	Yellow brown.	Pale olive.	Reddish.

The two papers, A and G, exhibit more sensitiveness to luminous influence than any others tried.

8. The paper, A, when washed with a weak solution of the hydriodate of baryta, gives under the pencil of light a beautiful picture, whether used in the camera or for surface drawings.

These pictures exhibit the peculiarities mentioned by Mr. Talbot at the British Association. Sunshine changes "the color of the object delineated from reddish to black with great rapidity." This gentleman adds, "after which no further change occurs."* Mr. Hunt, in remarking on this, says, "I have not been fortunate enough to succeed thus far in fixing my drawings. The continued influence of the light in a few months obliterates the impression." A singular change follows the exposure of these pictures to colored light.

If placed under vessels containing colored fluids, (4) and exposed either to sunshine or diffused light, in a few days the picture becomes a full *red* under the blue; a *rose hue* under the green; a *light blue* under the yellow, and a *deep blue* under the red. These colors, after deepening for some time, gradually change to different shades of green under the blue and green fluids, to a pink under the yellow, and a red under the red fluid (25.) After this, the colors alter no more, and the picture bears exposure to light much better than at first; but, it is doubtful if it is rendered permanent, for the dull light of January and February has spread a cloudiness like a mist, over those photographs which have been constantly exposed.

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* Athenæum, No. 618.

Daguerreotypes.

9. Exposing a plate, over which some lace was carefully placed, under four colored glasses (2.) for three minutes to diffused light, Mr. Hunt obtained, under the blue glass, a beautiful copy; no trace of a drawing beneath the green; a tolerable impression beneath the yellow; but the mercury would not attack the space beneath the red.

10. A plate similarly arranged beneath four bottles of colored fluid (4.) exposed to diffused light for fifteen minutes, was found, on being acted upon by the mercurial vapor, to present the same appearance as above, (9.) excepting that a faint design was evident over the space the carmine fluid had covered.

11. Mr. Hunt arranged a dark chamber, to which no other rays could pass but such as had permeated *two inches* of colored fluid.

Having filled the trough with a saturated solution of the bichromate of potash, he exposed a plate for five minutes to its influence in full sunshine. *There was not the slightest action.*

12. In one hour on a similar plate, under the same circumstances, he obtained a faint but still defined outline of a dried fern.

13. A bare iodidated plate, was exposed for two hours to the same influence. On removing it from the chamber, no difference was apparent; but it was found that it was no longer sensitive to light, and the iodide adhered more closely to the metal than it did. (28.)

This is a reverse action, for after the exposure of a prepared Daguerreotype plate to light, the sensitive film is most easily rubbed off.* (28.)

14. Red solutions impart a very decided rose hue, or more strictly speaking, the influence of red light on the iodidated plate occasions that peculiar arrangement of the mercurial particles, which is necessary to the production of red color.

15. Green solutions act with more or less effect in obstructing the passage of the so-called chemical rays, according to their depth of color. But in no instance has Mr. Hunt found them to produce that close combination which the yellow and sometimes the red fluids do, of the iodite and the under surface of unattacked silver. (28.) By examining the effects produced by green media (2, 7, 16) a peculiar order of interference will be remarked. (19.)

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* On this principle Mr. Hunt now polishes silvered plates, by which the troublesome process with nitric acid and pumice is got rid of. He washes the surface of silver over with a solution of the iodide of potassium holding a little iodine free, and rubs it lightly until all the parts are equally attacked. He then exposes the plate to light for a few minutes, and polishes off with dry cotton. In five minutes, by this process, the most perfect lustre may be given to the silver, and it has the advantage of rendering the plate more susceptible to the influence of the iodine vapor.

Germination and the Growth of Plants.

16. Mr. Hunt next planted, in a box, some curled cress seed, and so arranged bottles of carmine fluid, chromate of potash, acetate of copper, and the sulphate of ammonia, that all but a small space of the earth was exposed to light which had permeated three-fourths of an inch of these media.

For some days, the only apparent difference was that the earth continued damp under the green and blue fluids, whereas it rapidly dried under the red and yellow. The plumula burst the cuticle in the blue and green lights, before any change was evident in the other parts.

After ten days, under the blue fluid there was a crop of cress, of as bright a green as any which grew in full light, and *far more abundant.*

The crop was scanty under the green fluid, and of a pale unhealthy color. (15.)

Under the yellow solution but two or three plants appeared, yet they were less pale than those which had grown in green light. Beneath the red bottle the number of plants which grew was also small, although rather more than in the spot the yellow covered. They too were of an unhealthy color.

17. The order of the bottles was now reversed, by putting the red in the place of the blue, and the yellow in that of the green. After a few days exposure, the healthy cress appeared blighted, while a few more unhealthy plants began to show themselves from the influence of the blue rays, in the spot originally subjected to the red.

It is evident from this, that the red and yellow rays not merely retard germination, but positively destroy the vital principle in the seed. Prolonged exposure uncovered, with genial warmth, free air, and indeed all that can induce growth, fails to revive the blighted vegetation.

The experiments were many times repeated, varying the fluids, but the results have been the same. The above facts were strikingly exemplified where the space covered by the bichromate of potash was without a plant.

These results *merit the attention of those who are engaged in the study of vegetable economy.* Do not they point at a process by which the productions of climes more redolent of light than ours may be brought in this country to their native perfection?*

Dr. Draper's "experiments" (Philosophical Magazine, Feb. 1840, p. 81) "appear," says Mr. Hunt, "at variance with mine." "Under the influence of a nearly tropical sun permeating half an inch of solution of the bichromate of potash, cress grew of a green color, whilst it took five

* See end of chapter II., Part I.

days to give a sensitive paper a faint yellow green color. From this, Professor Draper argues the existence of two classes of rays, a different class being necessary to produce the green coloring of vegetable foliage from that which darkens chloride of silver.

"With submission," says Mr. Hunt, "to one whose facilities for such inquiries are so much greater than my own, I would suggest a repetition of the experiments with some of the *recently discovered photographic preparations*. The papers, *f*, and *h*, both under colored glass and great thicknesses of yellow fluid, are deepened to a plum brown in less than an hour."

Under three inches of the bichromate of potash, the paper, *f*, became, in eight hours sunshine, of a full blue-brown.

18. The fact of cress and pea-plants growing green, under the influence of such powerful light as penetrated Professor Draper's yellow media, will not appear at all surprising when we examine the rays which pass through such fluids.

This, Mr. Hunt has done by forming a spectrum, interposing the colored body between the prism and the sun. The following are the effects of February sun at Devonport.

Through a deep blue solution of the ammonia-sulphate of copper, the violet, indigo, blue, and a portion of the green rays pass.

Through solutions of the muriate, acetate, and nitro-muriate of copper with iron, the green ray, and a considerable portion of the yellow; a trace of the blue also is evident.

Through solutions of the bichromate and chromate of potash, the chloride of gold and decoction of turmeric, the red, the yellow, and the green rays are seen, *and by taking their impression on a Daguerreotype plate, a line of the blue is distinctly marked.*

Through nitro-muriate of cobalt in ammonia, carmine in ammonia, and sulphuric acid and decoction of cochineal, the red and yellow rays alone appear to penetrate.

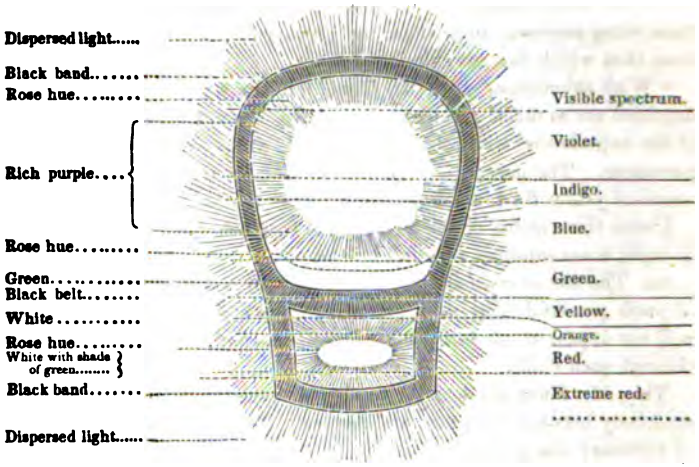
19. It will be observed, that the light which has passed through a green medium (2, 7, 9, 10, 15, 16.) acts less powerfully in darkening photographic papers, and occasions vegetable leaves to be even paler than that which has been subjected to the interference of a yellow medium.

From this Mr. Hunt was led to believe that the band of rays formed by the meeting of the yellow and the green has an influence similar to the extreme red, in neutralizing the powers of the other adjacent rays, as was first noticed by Sir John Herschel, (22,) (23,) (26.)

The annexed figure (49) represents the solar spectrum, as it impresses itself on a Daguerreotype plate, not in shadows merely, but in colors, which have the peculiar appearance of the down upon the nectarine.

The most refrangible portion of the spectrum is represented in full colors, shading from indigo to a delicate rose, which is lost in a band of pure white.

Fig. 49.



21. Beyond this a protecting influence is powerfully exerted, and notwithstanding the chemical effect produced over the plate, by the dispersed light, a line is formed free of mercurial vapor, and which consequently appears black.

22. The green portion of the spectrum is represented in its true color, but it is considerably less in size than the space occupied by these rays.

23. The yellow rays are without action, or rather they do not prepare the silver for the reception of the mercury, and consequently a black belt marks the space on which they fell, and extends a little beyond it into the green. (19.)

24. A white line marks the place of the orange light.

25. The red is represented by a well defined rose color, bounded, as were the more refrangible rays, by a white line, shaded, at the lower extremity, with a green.

This passing of the red into a green, and of the blue into a rose color, (20.) is strikingly similar to the effect produced, by the interference of colored media, on some photographic drawings. (8.)

26. The lowest dark space on the picture is a beautiful illustration of the influence of the extreme red rays in protecting the silver from luminous action. (19.) (21.)

27. What appears more surprising to me, says Mr. Hunt, than even the detection of the *negative?* rays at each end of the prismatic spectrum, is the continuation of the dark line throughout *its whole length*, evidently showing the influence of the same cause as is so effective at the least refrangible extremity.

This band is not equally defined throughout its entire circumference. It is the most strikingly evident from the extreme red to the green; it fades in passing through the blue, and increases in intensity as it leaves the indigo, until, beyond the invisible chemical rays, it is nearly as strong as it is at the calorific end of the spectrum.

Does not this protected surrounding band appear, says Mr. Hunt, to indicate the existence of rays of a peculiar and unknown order, proceeding from the extreme edge of the sun?—(See chapter II., Part I.)

28. By lightly rubbing a Daguerreotype picture of the prismatic rays, it is obliterated, except over the space of the yellow and red portion. This effect corresponds with Mr. Hunt's experiments on the media of these colors. (11, 12, 13.)

"Until we have more experience than we now have," says Mr. Hunt, "of the effects of the solar rays individually and collectively, we can offer no satisfactory explanation of the process in action, on a Daguerreotype plate, by which the subtle painter, *Light*, impresses such delicate designs."—(See chapter II, Part I.)

Mr. Hunt thinks that the existence of two iodides of silver, is certain. In his photometric experiments, he has always observed the formation of an iodide which speedily darkens, and of another portion which is unalterable by light.

The sensitive film on the silver plate appears to be the former of these iodides. Throughout the range of the chemical spectrum, *particularly so called*, the iodide is, according to Mr. Hunt, converted into an oxide of silver; that a partial oxidation takes place, numerous experiments have rendered certain; whilst the influence of the rays of least refrangibility is to form the unchangeable iodide of silver. Experiments, however, are wanting to prove this satisfactorily.

An attentive consideration of the facts which have now been enumerated, will, no doubt, satisfy all, that we can no longer with propriety attach the name of *chemical* to the most refrangible rays only. Every ray has its particular chemical office, either of composition or of decomposition; and although Seebeck has attributed the acquirement of a rose hue by chloride of silver when put into the red ray, to the heating power of that portion of the spectrum, it is now proved to be dependent upon some other influence, for where it has been shown the most calorific rays exist, this salt undergoes no change.—(See chapter II., Part I.)

F.

FAHRENHEIT.—(See *Thermometer*.)

FARINA is the flour of any species of corn, or starchy root, such as potato, arrow root, &c.—(See *Starch*.)

FERMENTATION.—This term has been of late extended to several chemical operations, besides those formerly included under it. The phenomena which it exhibits under these different phases, and the changes which it effects among the various subjects of its operation, are no less striking and mysterious in their principles than important in their applications to the arts of life. Fermentations are now arranged into twelve classes—1, the alcoholic; 2, the glucosic or saccharine; 3, the viscous or mucous; 4, the lactic; 5, the acetic; 6, the gallic; 7, the pectic; 8, the benzoilic; 9, the senapic; 10, the ammoniacal; 11, the putrid; and 12, the fatty.

Fermentation, in the most general sense, may be defined to be a spontaneous reaction, a chemical metamorphosis, excited in a mass of organic matter, by the mere presence of another substance, which neither abstracts from nor gives to the matter which it decomposes anything whatever. This process requires the following conditions:—1, A temperature from 45° to 90° F.; 2, Water; 3, The contact of air; 4, The presence of a neutral organic azotised matter, in very small quantity, and of a crystalizable non-azotised substance in considerable quantity. The former is the ferment, the latter undergoes fermentation. In ordinary chemical actions we perceive one body unite to another to form a new compound; or one body turn another out of a combination, and take its place, in virtue of a superior affinity. The effects are foreseen and explained by the intervention of that molecular force which governs all chemical operations, that attractive power which unites the particles of dissimilar bodies. Thus, also, in the ordinary phenomena of decomposition, we perceive the agency of heat at one time, at another of light, or of electricity; forces of which, though we are not acquainted with the essence, yet we know the exact effect under determinate circumstances. But fermentation, on the contrary, can be explained neither by the known laws of chemical affinity nor by the intervention of the powers of light, electricity, or heat. Fermentation reduces complex organic substances to simpler compounds, thereby reducing them nearer to the constitution of mineral nature. It is an operation analogous, in some respects, to that effected by animals upon their vegetable food.

Acid Fermentation has been fully discussed under acetic acid. It requires the presence of ready formed alcohol and air. The lactic fermentation, on the contrary, may take place with starchy or saccharine substances, without the intervention of alcohol or constant exposure to the atmosphere; and when once begun, it can go on without air. Acetification has a striking analogy with nitrification, as is shown by the necessity of a high temperature, and the utility of porous bodies for exposing the liquid on a great surface to the air.

Gallic Fermentation.—Gallic acid does not exist ready formed in galls, but is generated from their tannin when they are ground, made pasty

with water, and exposed to the air. This conversion may be counteracted by the red oxide of mercury, alcohol, sulphuric, muriatic, and nitric acids, brontine, essence of turpentine, creosote, oxalic, acetic, and prussic acids. The tannin disappears in the sequel of the above metamorphosis.

Ammoniacal Fermentation.—Under this title may be described the conversion of urea into carbonate of ammonia under the influence of water, a ferment, and a favorable temperature. Urea is composed in atoms; reckoned

In volumes,	Carbon 4;	hydrogen 8;	azote 4;	oxygen 2;
which by fixing	—	4;	—	2;
	—	—	—	—
give	4;	12;	4;	4:

which is 4 vol. of carbonic acid, and 8 of ammonia; equivalent to ordinary carbonate of ammonia. The fermentation of urea plays an important part in the reciprocal offices of vegetable and animal existence. By its conversion into carbonate of ammonia, urea becomes a food fit for plants; and by the intervention of the mucous ferment which urine contains, that conversion is effected. Thus the urea constitutes a neutral and innocuous substance while it remains in the bladder, but is changed into a volatile, alkaline, and acrid substance, when it is acted upon by the air. Yeast added to pure urea mixed with water, exercises no action on it in the course of several days; but when added to urine, it soon causes decomposition, with the formation of carbonate of ammonia, and disengagement of carbonic acid. The deposit on chamberpots ill-cleaned acts as a very powerful ferment on urine, causing the complete decomposition of fresh urine in one fifth of the time that would otherwise be requisite.

Nitrous Fermentation, is exhibited in the formation of nitric acid from the atmosphere, and the consequent production of nitrates in certain soils, has been with much probability traced to the action of ammonia on oxygen, as the intermedium or ferment.

For animal and vegetable matters to run into putrefaction, they must be in contact with air and water, at a certain temperature; viz., between the freezing and boiling points of water. The conract of a putrid substance, acts as a ferment to fresh animal and vegetable matters. The reagents which counteract fermentation in general stop also putrefaction. In this process, myriads of microscopic animalcules make their appearance, and contribute to the destruction of the substances.

FERRIC-CYANIDE OF POTASSIUM, or *Red Prussiate of Potash.*—This beautiful and useful salt, discovered by L. Gmelin, is prepared by passing chlorine gas through a weak solution of the prussiate of potash (ferro-cyanide of potassium) till it ceases to affect solution of red sul-

phate of iron, taking care to agitate the liquid all the while, and not to add an excess of chlorine. On looking through the weak solution to the flame of a candle, one may see the period of change from the greenish to the red hue, which indicates the completion of the process. The liquor being filtered and evaporated in a dish with upright sides, will eventually afford crystaline needles, possessed of an almost metallic lustre, and a yellow color, inclining to red. These being dissolved and recrystalized, will become extremely beautiful. This salt is composed of 33·68 parts of potassium, 16·48 of iron, and 47·84 of cyanogen. It is therefore a dry salt. It dissolves in 38 parts of cold water, and as it forms then the most delicate test of the protoxide of iron, is very useful in *Clorometry*.*

The solution of this salt affords the following colored precipitates with the solutions of the respective metals :—

Titanium	Brownish yellow.
Uranium	Reddish brown.
Manganese	Brownish gray.
Cobalt	Deep reddish brown.
Nickel	Yellowish brown.
Copper	Dirty yellowish brown.
Silver	Orange yellow.
Mercury	Yellow with both the protoxide and peroxide salts.
Tin	White.
Zinc	Orange yellow.
Bismuth	Yellowish brown.
Lead	No precip.
Iron, protoxide	Blue.
—— peroxide	No precip.

FERROCYANATE, or, more correctly, FERROCYANIDE.—Several compounds of cyanogen and metals possess the property of uniting together under double cyanides; of which there are none so remarkable in this respect, as the protocyanide of iron. This appears to be capable of combining with several simple cyanides, such as that of potassium, sodium, barium, strontium, calcium, and ammonium. The only one of these double cyanides of any importance in manufactures is the first, which is described under its commercial name *Prussiate of Potash*.—(See *Cyanide;* also chapter IV., Part I., chapter V., Part III., and chapter III., Part V.)

FIBRE.—One of the two bases of all vegetable structures. It may be compared to a hair of inconceivable fineness, its diameter often not exceeding 1-1200 of an inch; also the name of the finer divisions of roots.

* See chapter V., Part II.

FILTRATION, is a process, purely mechanical, for separating a liquid from the undissolved particles floating in it, which liquid may be either the useful part, as in vegetable infusions, or of no use, as the washing of mineral precipitates. The filtering substance may consist of any porous matter in a solid, foliated, or pulverulent form; as porous earthenware, unsized paper, cloth of many kinds, or sand. The white blotting paper sold by stationers, answers extremely well for filters in chemical experiments, provided it be previously washed with dilute muriatic acid, to remove some lime and iron that are generally present in it. Filter papers are first cut square, and then folded twice diagonally into the shape of a cornet, having the angular parts rounded off. Or the piece of paper being cut into a circle, may be folded fan-like, from the centre, with the folds placed exteriorly, and turned out sharp by the pressure of the finger and thumb, to keep intervals between the paper and the funnel into which it is fitted, to favor the percolation. The diameter of the funnel should be about three fourths of its height, measured from the neck to the edge. If it be more divergent, the slope will be too small for the ready efflux of the fluid. A filter covered with the sediment is most conveniently washed by spouting water upon it with a little syringe. A small camel's-hair paint brush is much employed for collecting and turning over the contents in their soft state. Agitation or vibration is of singular efficacy in quickening percolation, as it displaces the particles of the moistened powders, and opens up the pores which had become closed. Instead of a funnel, a cylindrical vessel may be employed, having its perforated bottom covered with a disc of filtering powder folded up at the edges, and made tight there by a wire ring. Linen or calico is used for weak alkaline liquors; and flannels, twilled woolen cloth, or felt-stuff, for weak acid ones. These filter bags are often made conical like a fool's cap, and have their mouths supported by a wooden or metallic hoop. Cotton wool put loose into the neck of a funnel answers well for filtering oils on the small scale. In the large way, oil is filtered in conical woolen bags, or in a cask with many conical tubes in its bottom, filled with tow or cotton wool. Stronger acid and alkaline liquors must be filtered through a layer of pounded glass, quartz, clean sand, or bruised charcoal. The alcarrhazas are a porous biscuit of stoneware made in Spain, which are convenient for filtering water, as also the porous filtering stone of Teneriffe, largely imported at one time, but now superseded in a great measure by the artificial filters patented under many forms, consisting essentially of strata of gravel, sand, and charcoal powder.

FULLERS' EARTH is a soft, friable, coarse or fine grained mass of lithomarge clay. Its color is greenish, or yellowish gray; it is dull, but assumes a fatty lustre upon pressure with the fingers, feels unctuous, does not adhere to the tongue, and has a specific gravity varying from

1·82 to 2·19. It falls down readily in water, into a fine powder, with extrication of air bubbles, and forms a non-plastic paste. It melts at a high heat into a brown slag. Its constituents are 53·0 silica; 10.0 alumina; 9·75 red oxide of iron; 1·25 magnesia; 0·5 lime; 24 water, with a trace of potash. Its cleansing action upon woolen stuffs depends upon its power of absorbing greasy matters. It should be neither tenacious nor sandy; for, in the first case, it would not diffuse itself well through water, and in the second it would abrade the cloth too much. The finely divided silica is one of its useful ingredients. The mode of preparing fullers' earth is as follows:—

After baking, it is thrown into cold water, where it falls into powder, and the separation of the coarse from the fine is effectually accomplished, by a simple method used in the dry color manufactories, called washing over. It is effected in the following manner:—Three or four tubs are connected on a line by spouts from their tops; in the first the earth is beat and stirred, and the water, which is continually running from the first to the last through intermediate ones, carries with it and deposits the fine whilst the coarse settles in the first.

The advantages to be derived from this operation are, that the two kinds will be much fitter for their respective purposes of cleansing coarse or fine cloth; for without baking the earth they would be unfit, as before noticed, to incorporate so minutely with the water in its native state; it would neither so readily fall down, nor so easily be divided into different qualities, without the process of washing over. When fuel is scarce for baking the earth, it is broken into pieces of the same size, as mentioned above, and then exposed to the heat of the sun.

The various uses of fullers' earth may be shortly explained. According to the above method, the coarse and fine of one pit being separated, the first is used for cloths of an inferior, and the second for those of a superior quality. The yellow and the blue earths are of different qualities naturally, and are, like the above, obtained artificially, and used for different purposes. The former, which is deemed the best, is employed in fulling the cassimers and finer cloths, whilst the blue is principally used for the coarser cloths. Its effect on these cloths is owing to the affinity which alumine has for greasy substances: it unites readily with them, and forms combinations which easily attach themselves to different stuffs, and thereby serve the purpose of mordants in some measure. The fullers generally apply it before they use the soap.

G.

GALL NUTS, SUBSTITUTE FOR.—Alphonse Rene Le Mire De Normandy, of London, recently obtained a patent for the following method "of superseding the use of gall-nuts, and of correcting the green and brown precipitates obtained from the combination of gallic acid and

sulphate of iron, as in the manufacture of the common black inks now in use." Instead of using gall-nuts, the acid is to be obtained from sumac, elm wood, chesnut, beech, willow, poplar, catechue, cherry, plum, or any other wood or berry, that contains gallic acid, or tannin, or both. The wood to be used, being first reduced to powder, is steeped in water, and combined with the hereinafter named substances, in about the following proportions. It should be observed, however, that the various woods require different quantities of water, according to their solubility; for instance, catechue, being nearly entirely soluble in water, will require a greater quantity than sumac; the patentee has therefore only given the proportions to be observed when sumac is used:—

To make 340 gallons of ink, take from 12 to 15 sacks of sumac, of four bushels to the sack, and having obtained the decoction, add 200 weight of campeachy; 80 lbs. or perhaps 100 weight of gum arabic; 100 weight of sulphate of protoxide of iron; acetate and hydrate of protoxide of copper, 4 lbs.; sulphate of alumine and potash, 37 lbs.; and of sulphate of indigo, 6 lbs.: the quantity of this latter may be regulated according to the required intensity of the color. If catechue is employed, then 100 weight will be found sufficient.*

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Gum senegal is collected by the negroes during the month of Novem-

* See *Tannin* and *Gallic Acid*, chapter II., Part III.

ber, from the *acacia senegal*, a tree of 18 or 20 feet high. It comes to us in pieces about the size of a partridge egg, but sometimes larger, with a hollow centre. Its specific gravity is 1·436. It is much employed in calico-printing.

Gum tragacanth is gathered about the end of June, from the *astragalus tragacantha* of Crete and the surrounding islands. It has the appearance of twisted ribbons; is white or reddish; nearly opaque, and a little ductile. It is difficult to pulverize, without heating the mortar. Its specific gravity is 1·384. It is also employed in calico-printing.

H.

HERMETIC SEAL.—When a vessel or tube is perfectly closed by fusing its mouth or extremity, it is said to be *hermetically sealed*.

HYDROMETER; an instrument for ascertaining the specific gravities of liquids. Baumé's hydrometer, which is much used in France, and other countries of the continent of Europe, when plunged in pure water, at the temperature of 58° Fahr., marks 0 upon its scale; in a solution containing 15 per cent. of common salt (chloride of sodium) and 85 of water by weight, it marks 15°; so that each degree is meant to indicate a density corresponding to one per cent. of that salt.—(See *Areometer*, and *Thermometer*.)

HYGROMETRIC.—This term is commonly applied to substances which readily become moist and dry with corresponding changes in the state of the atmosphere, or which readily absorb and retain moisture. Sea-weed, several saline substances, porous clays, potash and its carbonate, chloride of calcium, sulphuric acid, are in this sense of the term said to be *hygrometric*.

I.

INDIGO.—We intended to have given an additional article upon this subject here, but on further consideration have come to the conclusion that the subject has been sufficiently investigated, at least for any practical purpose.—(See chapter III., Part I., and chapter V., Part III.)

IRON MORDANTS.—"The principal simple preparations of iron which are employed as mordants are the following: copperas, which is the sulphate of the protoxide; iron liquor, which is an impure acetate of the protoxide; the pernitrate, the sub-persulphate, and the perchloride. The most available of these forms of iron is copperas; but this salt is not well adapted as a mordant for cotton goods, as the powerful affinity

of sulphuric acid for protoxide of iron is an impediment to the formation of an insoluble subsalt.

"*Acetate of Iron; Iron Liquor.*—The iron mordant commonly used in calico-printing is the acetate, which may be prepared by *mixing a solution of acetate of lime, or acetate of lead, with a solution of copperas.* A double decomposition occurs on the mixture of these solutions, with the formation of sulphate of lime or sulphate of lead, which falls as a heavy precipitate, and acetate of protoxide of iron, which remains in solution. For the complete decomposition of copperas by acetate of lead, 10 parts of the former require about 13½ parts of the latter; but in the preparation of acetate of iron in this way on the large scale, the copperas is always employed in excess, being seldom in so small a proportion to the acetate of lead as an equal weight. By exposure to the air the acetate of the protoxide becomes partially peroxidized, being converted into a subacetate of the peroxide.

"But nearly all the acetate of iron used in print-works is now prepared *by digesting, for several weeks, old iron hoops, nails, &c., in the crude acetic acid obtained by the distillation of wood.* A dark brown solution, known as the pyrolignite of iron or iron liquor, is thus obtained, composed of the acetate of the protoxide of iron, and a quantity of tarry, oily, and spirituous matters, produced in the destructive distillation of wood. As a mordant, this mixture is in general preferred to the purer article prepared by means of acetate of lead or acetate of lime, *probably because the peroxidation of the protoxide of iron by exposure to the air during the 'ageing' of the goods is retarded by the spirituous and unctuous matters present, which have a stronger affinity for the oxygen of the air.* A small quantity of the acetate of the peroxide of iron is sometimes contained in iron liquor, but by no means as an essential constituent.

"The principal pure persalt of iron used in dyeing and calico-printing is the nitrate, which is prepared by dissolving clean pieces of iron in nitric acid of specific gravity 1·305. Soon after the evolution of brown fumes ceases, the acid solution should be decanted, so as to avoid the formation of the insoluble sub-pernitrate of iron. This solution of iron is used as a mordant with vegetable coloring matters, and also for producing a buff color with an alkali, and Prussian blue with yellow prussiate of potash.

"A preparation of iron extensively employed at some print-works in the place of the common acid pernitrate, is a mixture of the neutral pernitrate with free acetic acid, obtained by adding about a pound of powdered acetate of lead to two pints of a solution of the pernitrate, of the density 1·55. The acetate of lead is decomposed by the free nitric acid present in the solution, with formation of nitrate of lead, which is precipitated, and free acetic acid.

"A solution of a sub-pernitrate of iron, made by adding a small quantity of an alkaline carbonate to the pernitrate, is also sometimes advantageously substituted for the pernitrate prepared as above. The peroxide of iron at first precipitated may be redissolved on agitation, if only a small proportion of alkali has been applied.

"Two other forms of peroxide of iron have been occasionally employed as mordants; one analogous in its chemical constitution to basic alum, and the other to red liquor. The first is prepared by partially decomposing, by means of an alkaline carbonate, the persulphate of iron, made by boiling copperas in dilute nitric acid. The oxide at first precipitated by the alkali is slowly redissolved by the undecomposed persulphate, giving rise to the subsulphate of the peroxide. The preparation of peroxide of iron, analogous to red liquor, may be made by adding one part, by weight, of acetate of lead, to four parts of a solution of persulphate of iron of the density 1·65. Sulphate of lead is precipitated, and the solution comes to contain subsulphate of the peroxide of iron, and peracetate of iron or free acetic acid."*—(See chapter I., Part III., article *Iron*.)

L.

LAZULITE (lapis lazuli) is a blue vitreous mineral, crystalizing in rhomboidal dodecahedrons; spec. grav., 2·76 to 2.94; scratches glass; affords a little water by calcination; fusible into a white glass; dissolves in acids with loss of color; the solution leaves an alkaline residuum, after being treated with carbonate of ammonia, filtered, evaporated, and calcined. It consists of silica, 35·8; alumina, 34·8; soda, 23·2; sulphur, 3·1; carbonate of lime, 3·1. This beautiful stone affords the native *ultramarine* pigment, which was very costly till a mode of making it artificially was lately discovered.—(See *Ultramarine*.)

LEMONS.—(See *Salts*.)

LICHENS.—Plants of a very low organization, which grow on the bark of trees or rocks, when they form a kind of incrustation; or upon the ground, when they consist of irregular lobes parallel with the earth's surface. Occasionally, in all situations, they are found in a branched state; but their subdivisions are generally irregular and without order. Their fructification consists of hard nuclei, called *shields*, which break through the upper surface of the *thallus* or main substance of the lichen, are of a peculiar color and texture, and contain the reproductive particles. Lichens abound in the cold and temperate parts of the world. Their principal use is that of furnishing the dyer with brilliant colors; archil, cudbear, &c.—(See chapter III., Part I.)

* Parnell.

LIGNEOUS.—In Entomology, a part is so called when it is composed of a hard inelastic substance like wood.

LIGNEOUS MATTER is vegetable fibre.—(See chapter V., Part I., article *Acetic Acid;* also *Pyroligneous Acid.*)

LITRE.—The French standard measure of capacity in the decimal system. The litre is a cubic decimetre; that is, a cube, each of the sides of which are 3·937 English inches: it contains 61·028 English cubic inches, and is therefore rather less than our *quart.* Four and a half litres are a close approach to the English imperial *gallon.*

LIXIVIATION signifies the abstraction by water of the soluble alkaline or saline matters present in any earthy admixture; as from that of quicklime and potashes to make potash ley, from that of effloresced alum schist to make aluminous liquor, &c.

M.

MACERATION, is a preparatory step to which certain vegetable and animal substances are submitted, with the view of distending their fibres or pores, and causing them to be penetrated by such menstrua as are best adapted to extract their soluble parts. Water alone, or mixed with acids, alkalies, or salts; alcohol and ether, are the liquors usually employed for that purpose.

MANGANESE, is a grayish white metal of a fine-grained fracture, very hard, very brittle, with considerable lustre, of spec. grav. 8·013, and requiring for fusion the extreme heat of 160° Wedgewood. It should be kept in closely stoppered bottles, under naphtha, like potassium, because with contact of air it speedily gets oxidized, and falls into powder. It decomposes water slowly at common temperatures, and rapidly at a red heat. Pure oxide of manganese can be reduced to the metallic state only in small quantities, by mixing it with lampblack and oil into a dough, and exposing the mixture to the intense heat of a smith's forge, in a luted crucible; which must be shaken occasionally to favor the agglomeration of the particles into a button. Thus procured, it contains, however, a little carbon. Manganese is never found native in the metallic state, the substance commonly known in the arts by that name being an impure oxide.

MANIPULATION, in Chemistry, embraces the manual and mechanical operations of the laboratory; and in the delicate details of analysis, as well as in the exhibition of class experiments, great skill and practice in manipulation are required to insure success. The processes of weighing, measuring, filtering, distilling, precipitating, dissolving, using the blowpipe, &c., all come within the meaning of manipulation. Dyeing and calico-printing, come equally within the meaning of this term.

MEASURE.—In a general sense, the term measure is applied to that by which anything is compared in respect of quantity. Thus, we have measures of extension, of weight, time, force, resistance, temperature, &c.; in short of everything of which greater and less can be predicated; and it frequently happens that the unit or measure is not taken in the thing or property which is the immediate subject of consideration, but in something else which depends on it, or is proportional to it. Angular space, for example, is measured by an arc of a circle; time, by the rotation of the earth about its axis, or its revolution about the sun; force, by the quantity of motion it impresses on a body; degrees of heat, by the expansion of metals or other substances; muscular strength, by the resistance of a spring, &c.

English system of Lineal Measures.—The unit of measure, as already stated, is the yard. The yard is divided into three feet, and the foot subdivided into 12 inches. The multiples of the yard are the pole or perch, the furlong and the mile; $5\frac{1}{2}$ yards being a pole, 40 poles a furlong, and 8 furlongs a mile. But the pole and furlong are now scarcely ever used, itinerary distances being reckoned in miles and yards. The relations of these different denominations are exhibited in the following table:—

In.	Feet.	Yards.	Poles.	Furlongs.	Miles.
1	0.083	0·028	0·00505	0·00012626	0·0000157828
12	1	0·333	0·06060	0·00151515	0·00018939
36	3	1	0·1818	0·004545	0·000568 18
198	16·5	5·5	1	0·025	0 003125
7920	660	220	40	1	0·125
63360	5280	1760	320	8	1

Measures of Superficies.—In square measure the yard is subdivided as in general measure into *feet* and *inches;* 144 square inches being equal to a square foot, and 9 square feet to a square yard. For land measure the multiples of the yard are the *pole*, the *rood*, and the *acre;* $30\frac{1}{4}$ (the square of $5\frac{1}{2}$) square yards being a pole, 40 poles a rood, and 4 roods an acre. Very large surfaces, as of whole countries, are expressed in square miles. The following are the relations of square measure.

Sq. feet.	Sq. Yards.	Poles.	Roods.	Acres.
1	0.1111	0·00367300	0·000091827	0·000022957
9	1.	0·0330579	0·000826448	0·000206612
272·25	30·25	1	0·025	0·00625
10890	1210	40	1	0·25
43560	4840	160	4	1

Measures of volume.—Solids are measured by cubic yards, feet, and inches; 1728 cubic inches making a cubic foot, and 27 cubic feet a cubic yard. For all sorts of liquids, corn, and other dry goods, the standard measure is declared by the act of 1824 to be the *imperial gallon*, the capacity of which is determined immediately by weight, and remotely by

sulphate of iron, as in the manufacture of the common black inks now in use." Instead of using gall-nuts, the acid is to be obtained from sumac, elm wood, chesnut, beech, willow, poplar, catechue, cherry, plum, or any other wood or berry, that contains gallic acid, or tannin, or both. The wood to be used, being first reduced to powder, is steeped in water, and combined with the hereinafter named substances, in about the following proportions. It should be observed, however, that the various woods require different quantities of water, according to their solubility; for instance, catechue, being nearly entirely soluble in water, will require a greater quantity than sumac; the patentee has therefore only given the proportions to be observed when sumac is used:—

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* See *Tannin* and *Gallic Acid*, chapter II., Part III.

adopted was to prefix the Greek numerals to the decimal multiples, and the Roman numerals to the decimal subdivisions.

The measures of length are as follows:—

Myriametre	=	10000 metres
Kilometre	=	1000
Hectometre	=	100
Metre	=	1
Decimetre	=	0·1
Centimetre	=	0·01
Millimetre	=	0·001

The measures of surface are,

Hectare	=	10000 sq. metres.
Are	=	100
Centiare	=	1

The measures of capacity are,

Kilolitre	=	1000 litres.
Hectolitre	=	100
Decalitre	=	10
Litre	=	1
Decilitre	=	0·1
Centilitre	=	0·01

The unit of solid measure is the *stere* or cube of the mètre, equal to 35·31658 English cubic feet.

No system of metrology hitherto invented can be compared with this of the French in a scientific point of view; nevertheless the decimal subdivisions have been found unsuited to the purposes of retail traffic, to which, in fact, only a binary system, or the division of the unit into halves and quarters, seems applicable. Accordingly, it has been found necessary to permit a modified system for such purposes; so that there are, in fact, at present in France three different systems of measures; the ancient, which was never wholly abandoned; the decimal system; and a binary system, or *système usuel*, having the decimal standards for its basis, with binary divisions, to which the names of the ancient weights and measures are given, the word *usuel* being annexed to prevent confusion.

Of the different measures of length used in European countries, the foot is the most universally prevalent. We subjoin the relation between the foot of different countries and the English foot, and which is as follows:—

	English foot.
Russian foot	= 1
Paris foot	= 1·065765
Prussian and Danish foot	= 1·029722
Bavarian foot	= 0·957561
Hanoverian foot	= 0·958333
Saxon foot	= 0·9°9118
Austrian foot	= 1·037128*

* See *Weight*.

MOTHER WATER.—A term applied by chemists to saline solutions from which crystals have been deposited, and which, when poured off and re-evaporated, furnish a second crop.—(See *Alum.*)

MURIATE OF AMMONIA.—Muriate of ammonia may be formed by mixing, over mercury, equal volumes of ammonia and muriatic acid gases, which will be entirely condensed into a white solid, which is the anhydrous salt; or it may be produced by neutralizing a solution of ammonia with solution of muriatic acid. Upon evaporation, the salt will be obtained in crystals containing, in addition, one equivalent of water. It is in this state that it is found in commerce under the name of *sal ammoniac.*—(See *Ammonia* and *Sal Ammoniac.*)

MURIATES OF TIN.—By boiling one part of tin with two of muriatic acid, a solution may be obtained, which yields by concentration a crop of deliquescent crystals, which consist of proto-muriate, or hydrated-protochloride of tin. The solution has a great attraction for oxygen, which it quickly absorbs from the air and from several metallic solutions which it deoxidizes and revives. It is used in the arts of dyeing and calico-printing. During the absorption of oxygen from the atmosphere, part of the tin is thrown down in the state of peroxide, and another part combines with a second equivalent of chlorine or muriatic acid, and *permuriate* or *perchloride* of tin remains in solution: the same solution may at once be obtained by dissolving tin in nitro-muriatic acid, or a mixture of nitric acid and common salt, or muriate of ammonia. It is also much used by dyers in producing scarlet with cochineal. The only muriates much used in the manufactures are *Muriate of ammonia*, or *Sal Ammoniac; Muriated peroxide of mercury; Mercury, bichlorade of; Muriate of soda*, or *Chloride of sodium; Muriate of tin.*—(See chapter I, Part III., article *Tin;* and chapter I, Part VI.)

MURIATE OF ZINC.—Muriatic acid dissolves zinc with facility; but the solution cannot be made to crystalize. When kept for some time on the sand bath till it ceased to lose weight, it concreted, on cooling, into a white opaque matter, having a very strong and disagreeable taste, and speedily deliquescing, when exposed to the air. It was analyzed, by Dr. Thomson, by dissolving a given weight in water, and precipitating the oxide of zinc by an alkali, and the muriatic acid by nitrate of silver. Its constituents are

1 atom muriatic acid	-	-	4·625
1 atom oxide of zinc	-	-	5·25
			9·875

N.

NAPHTHA.—A limpid bitumen, which exudes from the earth upon the shores of the Caspian and some other eastern countries. Near the village of Amiano, in the state of Parma, there exists a spring which yields this substance in sufficient quantity to illuminate the city of Genoa, for which purpose it is employed. It has a peculiar odor, and generally a yellow color, but may be rendered colorless by distillation. Its specific gravity is about 0·75. It boils at about 160°. It is highly inflammable, burning with a white smoky flame. It appears to be a compound of 36 of carbon with 5 of hydrogen, and is therefore a pure hydro-carbon. A liquid very similar to mineral naphtha is obtained by the distillation of coal tar. It has sometimes been used in lamps, but is apt to smoke. This variety of naphtha is in great request as a solvent for India rubber.

NEUTRALIZATION.—In chemistry, the combination of an acid and alkali in such proportions that the peculiar properties of each are rendered inert.

NEUTRAL SALTS.—Combinations of acids and bases which are neither acid nor alkaline, but in which the acid is exactly *neutralized* by the base.

NITRATES.—Salts of the nitric acid; thus *nitrate* of potassa is a compound of one atom of nitric acid and one atom of potassa.

O.

OIL OF TURPENTINE, sometimes called essence of turpentine. As found in commerce, it contains more or less rosin, from which it may be freed by re-distillation along with water. It is colorless, limpid, very fluid, and possessed of a very peculiar smell. Its specific gravity, when pure, is 0·870; that of the oil commonly sold is 0·875. It always reddens litmus paper, from containing a little succinic acid. According to Oppermann, the oil which has been repeatedly rectified over chloride of calcium, consists of 84·60 carbon, 11·735 hydrogen, and 3·67 oxygen. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. Chlorine inflames this oil; and muriatic acid converts it into a crystaline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

OLEIC ACID is the acid produced by saponifying olive oil, and then separating the base by dilute sulphuric or muriatic acid.

OX-GALL.—Painters in water colors, scourers of cloth, and many

others, employ ox-gall or bile; but when it is not purified, it is apt to do harm from the greenness of its own tint. It becomes therefore an important object to clarify it, and to make it limpid and transparent like water. The following process has been given for that purpose. Take the gall of newly killed oxen, and after having allowed it to settle for 12 or 15 hours in a basin, pour the supernatant liquor off the sediment into an evaporating dish of stone ware, and expose it to a boiling heat in a water bath, till it is somewhat thick. Then spread it upon a dish, and place it before a fire till it becomes nearly dry. In this state it may be kept for years in jelly pots covered with paper, without undergoing any alteration. When it is to be used, a piece of it of the size of a pea is to be dissolved in a table spoonful of water.

Another and probably a better mode of purifying ox-gall is the following. To a pint of the gall boiled and skimmed, add one ounce of fine alum in powder, and leave the mixture on the fire till the alum be dissolved. When cooled, pour into a bottle, which is to be loosely corked. Now take a like quantity of gall, also boiled and skimmed, add an ounce of common salt to it, and dissolve with heat; put it when cold into a bottle, which is likewise to be loosely corked. Either of these preparations may be kept for several years without their emitting a bad smell. After remaining three months, at a moderate temperature, they deposit a thick sediment, and become clearer, and fit for ordinary uses, but not for artists in water colors and miniatures, on account of their yellowish-green color. To obviate this inconvenience, each of the above liquors is to be decanted apart, after they have become perfectly settled, and the clear portion of both mixed together in equal parts. The yellow coloring matter still retained by the mixture coagulates immediately and precipitates, leaving the ox-gall perfectly purified and colorless. If wished to be still finer, it may be passed through filtering paper; but it becomes clearer with age, and never acquires a disagreeable smell, nor loses any of its good qualities.

Clarified ox-gall combines readily with coloring matters or pigments, and gives them solidity either by being mixed with or passed over them upon paper. It increases the brilliancy and the durability of ultramarine, carmine, green, and in general of all delicate colors, whilst it contributes to make them spread more evenly upon the paper, ivory, &c. When mixed with gum-arabic, it thickens the colors without communicating to them a disagreeable glistering appearance; it prevents the gum from cracking, and fixes the colors so well that others may be applied over them without degradation. Along with lampblack and gum, it forms a good imitation of China ink. When a coat of ox-gall is put upon drawings made with black lead or crayons, the lines can no longer be effaced, but may be painted over safely with a variety of colors previously mixed up with the same ox-gall.

Miniature painters find a great advantage in employing it; by passing it over ivory, it removes completely the unctuous matter from its surface; and when ground with the colors, it makes them spread with the greatest ease, and renders them fast. It serves also for transparencies. It is first passed over the varnished or oiled paper, and is allowed to dry. The colors mixed with the gall are then applied, and cannot afterwards be removed by any means. It is adapted finally for taking out spots of grease and oil.—(See chapter IV., Part V.)

OXIDATION or OXIDIZEMENT.—The act of combination with oxygen.

OXIDE.—Compounds containing oxygen, but which are not *acid*, have been termed *oxides*. The metallic oxides are a most important class of bodies. To designate the different oxides of one base we generally use the first syllable of the Greek ordinal numerals, designating the first, second, third, &c. oxides by the terms *protoxide*, *deutoxide*, *tritoxide*, &c.: and when the base is saturated with oxygen (still not acid) it is termed a *peroxide*. Compounds of bases with one atom and a half oxgygen, or of two base and three oxygen, are now generally distinguished by the term *sesquioxides*.

P.

PADDING, in calico-printing, is the impregnation of the cloth with a mordant.

PERCHLORIDE OF TIN.—(See *Calico-Printing*.)

PEROXIDE OF IRON.—(See *Mordants*, chapter I., Part III.)

PEROXIDE OF TIN.—(See chapter I., Part III., article *Tin*.)

POTASH or POTASSA.*—Potash is the most powerful of all the bases, and forms the most permanent combinations with the acids. For example:—The nitric acid sustains a much higher heat without decomposition, when united with this base, than with any other; and the vegetable acids also have their decomposition much retarded by the same combination.

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* So named from being prepared for commercial purposes by evaporating in iron pots the lixivium of the ashes of wood fuel. In the crude state, called potashes, it consists, therefore, of such constituents of burned vegetables as are very soluble in water, and fixed in the fire. The potash salts of plants which originally contained vegetable acids, will be converted into carbonates, the sulphates will become sulphites, sulphurets, or even carbonates, according to the manner of incineration; the nitrates will be changed into pure carbonates, while the muriates or chlorides will remain unaltered. Should quicklime be added to the solution of the ashes, a corresponding portion of caustic potassa will be introduced into the product, with more or less lime, according to the care taken in decanting off the clear ley for evaporation.

The potash of commerce is obtained in an impure state, by the incineration of vegetable matters, and hence is designated as the *vegetable* alkali. The purest is distinguished by the name of *pearlash*.

Pearlash is prepared by calcining potashes upon a reverberatory hearth, till the whole carbonaceous matter, and the greater part of the sulphur, be dissipated; then lixiviating the mass, in a cistern having a false bottom covered with straw, evaporating the clear ley to dryness in flat iron pans, and stirring it towards the end into white lumpy granulations.

All kinds of vegetables do not yield the same proportion of potassa. The more succulent the plant, the more does it afford; for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds are more productive of potash than the graminiferous species, or shrubs, and these than trees; and for a like reason, twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

The following TABLE exhibits the average product in potassa of several plants, according to the researches of Vauquelin, Pertuis, Kirwan, and De Saussure:—

In 1000 parts.	Potassa.	In 1000 parts.	Potassa.
Pine or fir	0·45	Dry beech bark	6·00
Poplar	0·75	Fern	6·26
Trefoil	0·75	Large Rush	7·22
Beechwood	1·45	Stalk of maize	17·50
Oak	1·53	Bastard chamomile (*Anthemis cotula*, L.)	19·60
Boxwood	2·26	Bean stalks	20·00
Willow	2·85	Sunflower stalks	20·00
Elm and maple	3·90	Common nettle	25·03
Wheat straw	3·90	Vetch plant	27·50
Barb of oak twigs	4·20	Thistles in full growth	35·37
Thistles	5·00	Dry straw of wheat before earing	47·00
Flax stems	5·00	Wormwood	73·00
Small rushes	5·08	Fumitory	79·00
Vine shoots	5·50		
Barley straw	5·80		

Stalks of tobacco, potatoes, chestnuts, chestnut husks, broom, heath, furze, tansy, sorrel, vine leaves, beet leaves, orach, and many other plants, abound in potash salts. In Burgundy, the well-known *cendres gravelées* are made by incinerating the lees of wine pressed into cakes, and dried in the sun; the ashes contain fully 16 per cent. of potassa.*

The purification of pearlash is founded upon the fact of its being more soluble in water than the neutral salts which debase it. Upon any given

* The best pink Canadian potashes, as imported in casks (containing about 5 cwts.), contains pretty uniformly 60 per cent. of absolute potassa; and the best pearlashes 50 per cent.; the alkali in the former being nearly in a caustic state; in the latter, carbonated.

quantity of that substance, in an iron pot, let one and a half times its weight of water be poured, and let a gentle heat be applied for a short time. When the whole has again cooled, the bottom will be incrusted with the salts, while a solution of nearly pure carbonate of potash will be found floating above, which may be drawn off clear by a syphon. The salts may be afterwards thrown upon a filter of gravel. If this ley be diluted with 6 times its bulk of water mixed with as much slaked lime as there was pearlash employed, and the mixture be boiled for an hour, the potash will become caustic, by giving up its carbonic acid to the lime. If the clear settled lixivium be now syphoned off, and concentrated by boiling in a covered iron pan, till it assumes the appearance of oil, it will constitute the common caustic of the surgeon, the *potassa fusa* of the shops. But to obtain potassa chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potassa, salts which, when carefully crystalized, are exempt from any thing to render the potassa derived from them impure. The bicarbonate having been gently ignited in a silver basin, is to be dissolved in 6 times its weight of water, and the solution is to be boiled for an hour, along with one pound of slacked lime for every pound of the bicarbonate used. The whole must be left to settle without contact of air. The supernatant ley is to be drawn off by a syphon, and evaporated in an iron or silver vessel provided with a small orifice in its close cover for the escape of the steam, till it assumes, as above, the appearance of oil, or till it be nearly red-hot. Let the fused potassa be now poured out upon a bright plate of iron, cut into pieces as soon as it concretes, and put up immediately in a bottle furnished with a well ground stopper. It is hydrate of potassa, being composed of 1 atom of potassa 48, + 1 atom of water 9, = 57.

A pure carbonate of potassa may be also prepared by fusing pure nitre in an earthen crucible, and projecting charcoal into it by small bits at a time, till it ceases to cause deflagration. Or a mixture of 10 parts of nitre and 1 of charcoal may be deflagrated in small successive portions in a red-hot deep crucible. When a mixture of 2 parts of tartrate of potassa, or crystals of tartar, and 1 of nitre, is deflagrated, pure carbonate of potassa remains mixed with charcoal, which by lixiviation, and the agency of quicklime, will afford a pure hydrate. Crystals of tartar calcined alone yield also a pure carbonate.

Caustic potassa after being fused in a silver crucible at a red heat, retains 1 prime equivalent of water. Hence its composition in 100 parts is, potassium 70, oxygen 14, water 16. Anhydrous potassa, or the oxide free from water, can be obtained only by the combustion of potassium in the open air. It is composed of 83⅓ of metal, and 16⅔ of oxygen. Berzelius's numbers are, 83·05 and 16·95.

Caustic potassa may be crystalized; but in general it occurs as a white brittle substance of spec. grav. 1·708, which melts at a red heat, evapo-

rates at a white heat, deliquesces into a liquid in the air, and attracts carbonic acid; is soluble in water and alcohol, forms soft soaps with fat oils, and soapy-looking compounds with resins and wax; dissolves sulphur, some metallic sulphurets, as those of antimony, arsenic, &c., as also silica, alumina, and certain other bases; and decomposes animal textures, as hair, wool, silk, horn, skin, &c. It should never be touched with the tongue or the fingers.

If one part of carbonate of potash be dissolved in four parts of water, and the solution be boiled with slacked lime, the potash does not lose the smallest quantity of carbonic acid; it does not become caustic, even though lime be added to any extent, or however long the boiling may be continued. If, however, 6 parts of water be gradually added to the above mixture, it will be found, and without farther boiling, that the potash loses its carbonic acid gradually; and that after the addition of the last portion of water, the potash is perfectly caustic. If the water be added at once, the potash becomes very quickly caustic.

This peculiarity is explained, by the fact, that concentrated caustic potash takes carbonic acid from lime. This fact is readily proved by boiling powdered chalk with concentrated potash, entirely free from carbonic acid; the solution added to muriatic acid occasions brisk effervescence. M. Liebig states that the carbonate of potash which is to be made caustic should be dissolved in at least 10 parts of water.*

The following TABLE exhibits the quantity of *Fused Potassa* in 100 parts of *caustic ley*,† at the respective densities:—

Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.
1·58	53·06	1·46	42·31	1·34	32·14	1·22	23·14	1·10	11·28
1·56	51·58	1·44	40·17	1·32	30·74	1·20	21·25	1·08	9·20
1·54	50·09	1·42	37·97	1·30	29·34	1·18	19·34	1·06	7·02
1·52	48·46	1·40	35·99	1·28	27·86	1·16	17·40	1·04	4·77
1·50	46·45	1·38	34·74	1·26	26·34	1·14	15·38	1·02	2·44
1·48	44·40	1·36	33·46	1·24	24.77	1·12	13.30	1·00	0·00

The only certain way of determining the quantity of free potassa in any solid or liquid, is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potassa, or its ley, often contains a notable quantity of carbonate, the presence of which may be detected by lime water, and its amount be ascertained by the loss of weight which it suffers, when a

* *Ann. de Chim. et de Phys.*

† M. Bizio states that the best method of rendering potash and soda caustic, is to mix a solution of one part of the dry alkaline carbonate with one part freshly prepared hydrate of lime, and allowing it to stand in a close vessel for twenty-four hours, at a temperature of from 68 deg. to 70 deg. Fahr., shaking it frequently. The potash salt should be dissolved in 12 to 15, the soda salt in 7 to 13 parts of water; the carbonate of lime separates in a granular state, and the clear caustic ley may be decanted.

weighed portion of the ley is poured into a weighed portion of dilute sulphuric acid poised in the scale of a balance.

There are two other oxides of potassium; the suboxide, which consists, according to Berzelius, of 90·74 of metal, and 9·26 oxygen; and the hyperoxide, an orange-yellow substance, which gives off oxygen in the act of dissolving in water, and becomes potassa. It consists of 62 of metal, and 38 of oxygen.

Carbonate of potassa is composed of 48 parts of base, and 22 of acid, according to most British authorities: or, in 100 parts, of 68·57 and 31·43; but according to Berzelius, of 68·09 and 31·91.

Carbonate of potassa, as it exists associated with carbon in calcined tartar, passes very readily into the *Bicarbonate*,* on being moistened with water, and having a current of carbonic acid gas passed through it. The absorption takes place so rapidly, that the mass becomes hot, and therefore ought to be surrounded with cold water. The salt should then be dissolved in the smallest quantity of water at 120° F., filtered, and crystalized.

POTTER'S CLAY, or PLASTIC CLAY.—This species is compact, soft, or even unctuous to the touch, and polishes with the pressure of the finger; it forms, with water, a tenacious, very ductile, and somewhat translucent paste. It is infusible in a porcelain kiln, but assumes in it a great degree of hardness. Werner calls it *pipe-clay*. Good plastic clay remains white, or if gray before, becomes white in the porcelain kiln.—(See *Clay*.)

PRECIPITATE.—A result of chemical decomposition, in which a substance is *thrown down* in a solid, and generally in a finely divided state, from a liquid.

PRECIPITATION, is the actual subsidence of a precipitate.

PROTOXIDE OF COPPER, or RED OXIDE OF COPPER: its color is a deep red, sometimes very lively, especially when bruised. It is friable, difficult of fusion at the blowpipe, reducible on burning charcoal, soluble with effervescence in nitric acid, forming a green liquid. Its constitution, when pure, is 88·9 copper + 11·1 oxygen = 100.†

PROTOXIDE OF IRON.—(See chapter IV., Part I., and chapter I., Part III.)

PROTOXIDE OF TIN.—(See chapter I., Part III., article *Tin*.)

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* When a solution of the bicarbonate of potash is boiled till carbonic acid is no longer given off, it forms, on cooling, deliquescent crystals, which are insoluble in alcohol. They contain six equivalents of water, and one and a half equivalent of acid to one of the base. The same salt may be procured by dissolving 100 parts of carbonate, and 131 parts of bicarbonate of potash in water.

† *Black oxide of copper* is of a velvet black, inclining sometimes to brown or blue; and it acquires the metallic lustre on being rubbed. It is infusible at the blowpipe. Its composition is, copper 80 + oxygen 20; being a true peroxide.

PUTREFACTION.—The decomposition of animal bodies, or of such plants as contain azote in their composition, which takes place spontaneously when they are exposed to the air, under the influence of moisture and warmth, is called putrefaction. During this process, there is a complete transposition of the proximate principles, the elementary substances combining in new and principally gaseous compounds. Oxygen is absorbed from the atmosphere, and converted into carbonic acid; one portion of the hydrogen forms water with the oxygen; another portion forms, with the azote, the carbon, the phosphorus, and the sulphur respectively, ammonia, carbureted, phosphureted, and sulphureted hydrogen gases, which occasion the nauseous smell evolved by putrefying bodies. There remains a friable earthy-looking residuum, consisting of rotton mould and charcoal. Vegetables which contain no azote, like the ligneous part of plants, suffer their corresponding decomposition much more slowly, and with different modifications, but they are finally converted into vegetable mould. In this process, the juices with which the plants are filled first enter into the acetous fermentation under the action of heat and moisture; the acid thereby generated destroys the cohesion of the fibrous matter, and thus reduces the solids to a pulpy state. In the progress of the decomposition, a substance is lastly produced which resembles oxidized extractive, is soluble in alkalies, and is sometimes called *mould*. This decompositions of the plant which contain no azote, goes on without any offensive smell, as none of the above-named nauseous gases are disengaged. When vegetable matters are mixed with animal, as in the dung of cattle, this decomposition proceeds more rapidly, because the animalized portion serves as a ferment to the vegetable. Vegetable acids, resins, fats, and volatilized oils, are not of themselves subject to putrefaction.

PRUSSIAN BLUE (*rendered more soluble*).—We are indebted to Messrs. Nash and Stephens, of London, for the following process of treating, or operating upon Prussian blue, *so as to render it more perfectly soluble*, or more readily disposed to be acted upon by the subsequent process of solution, than when manufactured in the usual way. This most desirable object, these gentlemen tell us they effect in the following manner:—

"We take the *Prussian blue*, whether produced from a combination of prussiate of potash and salts of iron, or the Prussian blue of commerce, as commonly manufactured, and we put this into an earthen vessel, and pour over it a quantity of strongly-concentrated acid, sufficient to cover the Prussian blue. Muriatic acid, sulphuric acid, or any other acid which has a sufficient action upon iron, will do. If sulphuric acid is used, it should be diluted a little, that is, with a quantity of water *equal to about its bulk* at the time when the mass turns white after the Prussian blue is put in. The Prussian blue is to be allowed to remain in the acid from twenty-four to forty-eight hours or longer. We then dilute this mixture with a large quantity of water, stirring it up at the time for the purpose of washing from it the salts of iron. When in this state of dilution we suffer it to stand until the color has subsided, when the supernatant liquor is to be drawn off with a syphon, and more water added to it,

and we continue the repetition of this process until we judge that the acid with the iron has been completely washed away, and this is known by testing it with prussiate of potash, which will show if it yields any blue precipitate, if not it is sufficiently washed; we then place it upon a filter and suffer it to remain until the liquid has all drained away. The Prussian blue thus prepared is reduced to a state as we conceive, *containing less iron than the Prussian blue of commerce*, in which state it is more readily acted upon and rendered soluble than in any other condition. This Prussian blue may be then placed in evaporating dishes and gently dried. To form the Prussian blue so operated upon, into a solution, we add to it oxalic acid, and mix them carefully together, after which we add cold water (cold distilled water is best) a little at a time, making into a dense or dilute solution according to the color required. The quantity of oxalic acid may vary according to the quantity of water used. It will be found that the Prussian blue that has undergone the process of digestion as described, requires but a small quantity of oxalic acid, to dissolve it. About *one part of oxalic acid* will dissolve *six parts of Prussian blue* (the weight being taken before digesting in the acid); this will answer for a concentrated solution, but for a dilute solution more acid will be required."

Prussian blue that has not undergone digestion in acid, in the way above pointed out, will require a much larger portion of oxalic acid, from twice to three times its weight, and even then it will be greatly liable to precipitate after standing; *but when treated in the way described, it is not*, according to Messrs. Nash and Stephens, *liable to precipitate, but remains a permanent solution.*

"The chief obstacle to the general employment of the beautiful color obtained by means of the ferro-prussiates to the purposes of dyeing, says these gentlemen, has been its hitherto supposed insoluble nature; but by means of oxalic acid (whether obtained by the usual process of mixing or distilling saccharine matter in combination with nitric acid, or from vegetable or other substances containing oxalic acid, or from combinations of oxalates, whether metallic, earthy, or alkaline) we obtain the above *perfect solution of the Prussian blue*, which is applicable to dyeing, coloring, or staining in the various manufactures of woolens, silks, linen, cotton, paper, and such other substances as are required to be dyed or stained."—(See chapter V., Part III., and chapter III., Part V.)

PYROMETER is the name of an instrument for measuring high degrees of heat above the range of the mercurial thermometer. Wedgewood's is the one commonly referred to by writers upon porcelain and metallurgy, but a better one might be easily contrived.

R.

RED LIQUOR AND ACETATE OF ALUMINA.—Red liquor is much more extensively employed as a mordant than any other preparation of alumina. The common method of preparing this liquid for the use of the dyer and calico-printer is by adding a solution of acetate of lead or acetate of lime to a solution of alum, when a portion of the sulphuric acid of the alum combines with the oxide of lead or the lime of

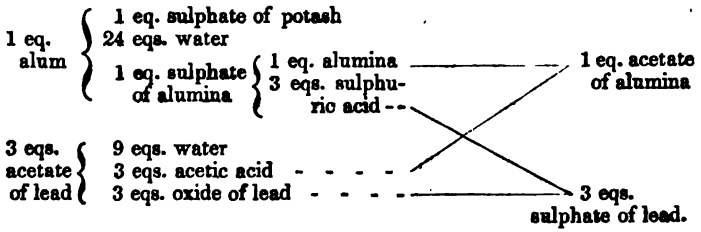
the acetate to form an insoluble sulphate, and the acetic acid previously in combination with oxide of lead or lime combines with alumina to form a soluble acetate. To produce complete decomposition both of the sulphate of alumina and the sulphate of potash in the alum, with formation of sulphate of lead and acetates of alumina and potash,

478 parts, or 1 eq. of alum, require
756 parts, or 4 eqs. of crystallized acetate of lead.

And for the complete decomposition only of the sulphate of alumina in the alum,

478 parts, or 1 eq. of alum, require
567 parts, or 3 eqs. of crystallized acetate of lead.

The reactions which occur on mixing solutions of these materials in the latter proportions are expressed in the following diagram :—



But the quantity of acetate of lead employed in the preparation of red liquor is never greater than that of the alum, and commonly one-third less, the proportions being slightly varied according to the purposes for which the mordant is required. A small quantity of carbonate of soda (from one-twentieth to one-tenth of the weight of the alum) is also sometimes added to the mixture to separate a portion of the sulphuric acid contained in the excess of alum.

The following proportions of the materials afford a strong mordant of specific gravity about 20° Twaddell* (1,100), well adapted for producing dark reds with madder.

No. 1.

5 gallons of water,
10 pounds of alum,
1 pound of soda crystals,
10 pounds of acetate of lead.

The alum is first dissolved in boiling water, and to this solution the soda is added gradually; when the effervescence is subsided, the acetate of lead is added in a state of fine powder, and the mixture having been

* Degrees on Twaddell's hydrometer may be converted into the ordinary sp. gr. formula (water being 1,000) by multiplying them by 5 and adding 1,000.

well agitated is allowed to stand for the sulphate of lead to settle, after which the supernatant liquid may be decanted for use.

A red liquor, better adapted than the above for producing a yellow dye with the coloring matter of quercitron, may be made by mixing, in the same manner,

No. 2.

5 gallons of water,
10 pounds of alum,
1 pound of soda,
7½ pounds of acetate of lead.

In consequence of the expense of acetate of lead, this salt is commonly superseded, in the preparation of red liquor, by acetate of lime, obtained by neutralizing with quick-lime the crude acetic acid or pyroligneous acid afforded by the distillation of wood; but the red liquor thus prepared does not produce with coloring matters such delicate and bright shades as that prepared by acetate of lead. The usual proportions of acetate of lime and alum employed for this purpose are two pounds and a half of the latter to a gallon of solution of the former of specific gravity 12° or 13° Twaddell. As met with in commerce, red liquor usually has a spec. grav. about 18° Twad.

The following mode of preparing red liquor by acetate of lime is recommended by M. Kœchlin-Schouch (*Bulletin de la Société Industrielle de Mulhausen*, t. i. p. 277.) In twenty-five gallons of hot water dissolve two hundred pounds of alum, and to the solution add three hundred pounds of the crude solution of acetate of lime of specific gravity 16° Twad. The resulting red liquor has the density, while hot, of 22° Twad., but on cooling it deposites crystals of alum, and falls in specific gravity to 18° Twad.

In neither of the preceding preparations is sufficient acetate of lead or acetate of lime employed to decompose the whole of the sulphate of alumina in the alum, and it is doubtful, moreover, whether acetate of lime, in any quantity, would effect the complete decomposition of sulphate of alumina. But this undecomposed alum or sulphate of alumina, instead of being useless as some have supposed, forms a highly important constituent of the mixture. By its action on the acetate of alumina in the solution, it gives rise to the formation of subsulphate of alumina or basic alum, and free acetic acid, and the latter serves to retain the former in a state of more permanent solution than water would alone.

On applying heat to red liquor, a precipitate of subsulphate of alumina is produced in the liquid, containing, according to the analysis of M. Kœchlin-Schouch, eight equivalents of alumina and three equivalents of sulphuric acid, or, eight times as much alumina as the neutral sulphate in common alum. The temperature at which the precipitation com-

mences varies according to the strength of the liquor and the proportions of acetate of lead and alum employed in its preparation. When made as No. 1, page 665, the precipitation commences at about 154° Fahr. If the source of heat is withdrawn soon after the precipitate appears, so as to avoid the evaporation of acetic acid and the aggregation of the precipitate, the latter completely redissolves as the liquid cools; but if the heating is continued until a sensible quantity of the acetic acid is evaporated and the precipitate is become dense, the subsulphate does not redissolve on cooling, nor even on the addition of free acetic acid. Such a precipitation of insoluble subsulphate, accompanied with the evaporation of acetic acid, always occurs during the drying and "ageing" of cottons printed with red liquors.*

A solution of pure acetate of alumina obtained by dissolving recently precipitated hydrate of alumina in acetic acid is uncrystalizable, and dries, on evaporation, into a gummy mass, very soluble in water. The aqueous solution of the pure acetate may be boiled without decomposition; but if a solution of alum is added to acetate of alumina, so as to form a mixture analogous to red liquor, the liquid affords, on the application of heat, a precipitate of subsulphate, of the same composition as that produced from common red liquor, which redissolves on the cooling of the liquid if the acetic acid has not been expelled.

Acetate of alumina made without excess of alum is very rarely used as a mordant, the proportions of alum and acetate of lead employed in almost all cases being four parts of the former to three parts of the latter. The chief use of the pure acetate, or rather of the mixture of pure acetate with sulphate of potash, such as is obtained by mixing eight parts of alum with nine and a half parts of acetate of lead, is to add to mixtures for topical colors containing a strong acid, such as muriatic, sulphuric, or nitric, in the free state. The strong acid combines with the alumina of the acetate, and liberates acetic acid, which exerts no corrosive action on the fibre of the cloth.†

S.

SAL AMMONIAC.—The manufacture of this salt may be traced to the remotest era. Its name is derived from Ammonia, or the temple of Jupiter Ammon, in Egypt, near to which the salt was originally made. Sal ammoniac exists ready formed in several animal products. The dung and urine of camels contain a sufficient quantity to have ren-

* Concentrated red liquor deposits a small quantity of the bisulphate of alumina at common temperatures, if kept for a considerable time. The precipitate thus gradually formed is sometimes too aggregated to be redissolved on the application of acetic acid.

† Applied Chemistry, p. 114.

dered its extraction from them a profitable Egyptian art in former times, in order to supply Europe with the article. In that part of Africa, fuel being very scarce, recourse is had to the dung of these animals, which is dried for that purpose, by plastering it upon the walls. When this is afterwards burned in a peculiar kind of furnace, it exhales a thick smoke, replete with sal ammoniac in vapor; the soot of course contains a portion of that salt, condensed along with other products of combustion. In every part of Egypt, but especially in the Delta, peasants are seen driving asses loaded with bags of that soot, on their way to the sal ammoniac works.

The best white sal ammoniac is in spheroidal cakes of about one foot diameter, three or four inches thick in the middle, somewhat thinner at the edges, and is semi-transparent or translucent. Each lump weighs about one quarter of a cwt. As it is easily volatilized by heat, it may be readily examined as to its sophistication with other salts. Sal ammoniac has a certain tenacity, and is flexible under the hammer or pestle.—(See chapter I., Part IV.)

SALOP.—(See *Calico Printing*.)

SALT.—This term, though in ordinary language limited to common salt, or sea salt, is applied in chemistry to all combinations of acids with alkaline or salifiable bases. The term has also been extended to certain binary combinations of chlorine, iodine, bromine, and fluorine with the metals; and these have been called *haloid salts*, inasmuch as modern chemistry has taught us that sea salt belongs to this class. Certain definite combinations of the sulphurets with each other have of late been called *sulphur salts;* but the former appellation of *double sulphurets* is, perhaps, more properly applicable to such compounds. Sea salt is a compound of 1 equivalent of sodium = 24, and 1 of chlorine = 36; its equivalent, therefore, is (24 + 36) = 60: and it is a chloride of sodium. The circumstances which gave rise to the notion of its containing muriatic acid and soda, and being therefore a muriate of soda, will be apparent by reference to the article *Muriatic Acid*, chapter V., Part I.

The nomenclature of salts has reference to the acids which they contain; *sulphates*, *nitrates*, *carbonates*, &c., implying salts of the sulphuric, nitric, and carbonic acids. The termination *ate* implies the maximum of oxygen in the acids, and *ite* the minimum: thus the salts of sulphurous and nitrous acids are called *sulphites* and *nitrites*. When salts contain 1 equivalent of acid and 1 of base, they are called *neutral salts;* where 1 equivalent of acid is combined with 2 of base, they are termed *basic salts*, *subsalts*, or *disalts;* and where there are 2 equivalents of acid and 1 of base, the salt is a *supersalt*, or *bisalt*. Thus, the terms *subacetate* and *diacetate of lead* are synonymous: so are *supercarbonate* and *bicarbonate of potash*. Many salts are *hydrous;* that is, they contain a definite proportion of water of crystalization; others are destitute of

water, and are dry or *anhydrous salts*. Some salts attract moisture when exposed to air, and are said to be *deliquescent*; others suffer their water to escape and become opaque, or pulverulent: they are called *efflorescent salts*.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF LEMONS, is citric acid.

SALT OF SATURN, is acetate of lead.

SALT OF SODA, is carbonate of soda.

SALT OF SORREL, is bi-oxalate of potassa.

SALT OF TARTAR, is carbonate of potassa.

SALT OF VITRIOL, is sulphate of zinc.

SALT PERLATE, is phosphate of soda.

SALTPETRE, is nitre, or nitrate of potassa.

SATURATION is the term at which any body has taken its full dose or chemical proportion of any other with which it can combine; as water with a salt, or an acid with an alkali in the neutro-saline state.

SCHEELE'S GREEN is a pulverulent arsenite of copper, which may be prepared as follows:—Form, first, an arsenite of potassa, by adding gradually 11 ounces of arsenious acid to 2 pounds of carbonate of potassa, dissolved in 10 pounds of boiling water; next, dissolve 2 pounds of crystalized sulphate of copper in 30 pounds of water; filter each solution, then pour the first progressively into the second, as long as it produces a rich grass-green precipitate. This being thrown upon a filter-cloth, and edulcorated with warm water, will afford 1 pound 6 ounces of this beautiful pigment. It consists of, oxide of copper 28·51, and of arsenious acid 71·46. This green is applied by an analogous double decomposition to cloth.

SILICATES are compounds of silicic acid (silica), with the bases alumina, lime, magnesia, potassa, soda, &c. They constitute the greater number by far of the hard minerals which incrust the terrestrial globe. Thus cyanite is a subsilicate of alumina; feldspar and leucite, are silicates of alumina and potassa; albite and analcime, are silicates of alumina and soda; stilbite, prehnite, mesolite, labradorite, tourmaline, mica, &c., are silicates of alumina and lime; chrysolite, steatite, serpentine, and meerschaum, are silicates of magnesia; augite and hornblende, are silicates of lime and magnesia, &c.

SOAP.—The chemical nature of soap has been laboriously examined by Chevreul, who has shown that the alkali in the process of saponification converts the oil into peculiar *acids*, as he terms them; the elain of the oil forming *oleic acid*, and the stearine *margaric acid*: so that soluble soaps are oleates and margarates of soda and potash. He has enumerated several other fatty acids similarly produced.

All new soaps contain a considerable portion of adhering water, a

great part of which they lose when kept in a dry place; hence the economy and excellence of *old* soap; and hence the dealers in soap generally keep it in a damp cellar, that it may not lose weight by evaporation; or, as it is said, sometimes immerse it in brine, which does not dissolve it, but keeps it in its utmost state of humidity.

Soap may be considered as a necessary of life; in all civilized countries its consumption is immense. According to Pliny, the invention of soap must be ascribed to the Gauls, by whom, he says, it was composed of tallow and ashes, though the German soap was considered the best. Hence the Latin *sapo*, which by a slight transposition of letters has become *soap*, is probably derived from the old German *sepe* (now written *seife.*)

Mrs. Laura Laughton, of Everton, County of Nottingham, obtained a patent in November, 1845, for "certain improvements in the manufacture of soap." The invention consists in combining with soap, which has been made in the ordinary manner; a solution prepared from quick-lime, fullers' earth, and water.

The mode of preparing the solution is as follows:—Upon one pound of quick-lime, two gallons of cold rain water are poured, and, after standing for about twelve hours, the clear lime water is drawn off; then, on four ounces of fullers' earth, two gallons of boiling rain water are poured, and the two solutions are mixed together. One pint of the combined solution is added to each pound of soap, when in a melted state, and thoroughly combined therewith by stirring; when cool, the mixture is fit for use.

Several other patents have been granted within a few years past, "for improvements in the manufacture of soap," and "for substitutes for soap," but those processes do not seem to have answered the purposes proposed by the different patentees, and consequently nearly all those schemes by which they expected to realise immense fortunes, have fallen into disuse or become altogether extinct.

SODA, *Caustic soda*, is an alkaline substance, used in chemical researches, in bleaching, and in the manufacture of soap. It is prepared by boiling a solution of crystalized carbonate of soda in 4 or 5 parts of water, with half its weight of recently slacked and sifted lime. At the end of half an hour, the vessel of iron, porcelain, or preferably silver, may be removed from the fire, and covered carefully, till the calcareous matter has settled into a solid magma at the bottom. The clear supernatant ley may then be decanted into bottles for use in the liquid state, or evaporated, out of contact of air, till it assumes an oily appearance, then poured upon an iron or marble slab, broken into pieces, and put up in vials secured with greased stoppers or corks.

Caustic soda is a white brittle mass, of a fibrous texture, a specific gravity of 1·536, melting at a heat under redness, having a most corrosive taste and action upon animal matters, dissolving readily in both water

and alcohol, attracting carbonic acid when exposed to the atmosphere, but hardly any water, and falling thereby into an efflorescent carbonate; it forms soaps with tallow, oils, wax, rosin; dissolves wool, hair, silk, horn, alumina, silica, sulphur, and some metallic sulphurets. It consists of 77·66 soda, and 22·34 water. A solution of caustic soda affords no precipitate with solution of chloride of platinum, or tartaric acid, as a solution of caustic potash never fails to do.

The following TABLE of the quantity of CAUSTIC SODA contained in LEYS of different densities, has been given by Richter:—

Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.
1·00	0·00	1·12	11.10	1·22	20·66	1 32	29·96
1·02	2·07	1·14	12·81	1·24	22·58	1·34	31·67
1·04	4·02	1·16	14·73	1·26	24·47	1·35	32·40
1·06	5·89	1·18	16·73	1·28	26·33	1·36	33·08
1·08	7·69	1·20	18·71	1·30	28·16	1·38	34·41
1·10	9·43						

Crystalized carbonate of soda contains 62¾ per cent. of water. The crystals are colorless transparent rhomboids, which readily effloresce in the air, and melt in their own water of crystalization. On decanting the liquid from the fused mass, it is found that one part of the salt has given up its water of crystalization to another. By evaporation of that fluid, crystals containing one-fifth less water than the common carbonate are obtained. These do not effloresce in the air.

SPECIFIC GRAVITY, designates the relative weights of different bodies under the same bulk; thus a cubic foot of water weighs 1000 ounces avoirdupois; a cubic foot of coal, 1350; a cubic foot of cast-iron, 7,280; a cubic foot of silver, 10,400; and a cubic foot of pure gold, 19,200; numbers which represent the specific gravities of the respective substances, compared to water = 1·000.—(See *Areometer of Baumé.*)

STARCH, is a white pulverulent substance, composed of microscopic spheroids, which are bags containing the amylaceous matter. It exists in a great many different plants, and varies merely in the form and size of its microscopic particles; as found in some plants, it consists of spherical particles $\frac{1}{1000}$ of an inch in diameter; and in others, of ovoid particles, of $\frac{1}{300}$ or $\frac{1}{400}$ of an inch. It occurs, 1. in the seeds of all the acotyledinous plants, among which are the several species of corns, and those of other *gramineæ;* 2. in the round perennial tap-roots, which shoot up an annual stem; in the tuberose roots, such as potatoes, the *Convolvulus batatas* and *edulis*, the *Helianthus tuberosus*, the *Jatropha manihot*, &c., which contain a great quantity of it; 3. in the stems of several monocotyledinous plants, especially of the palm tribe, whence sago comes; but it is very rarely found in the stems and branches of the dicotyledinous plants; 4. it occurs in many species of lichen. Three kinds of

starch have been distinguished by chemists; that of wheat, that called *inuline*, and lichen starch. These three agree in being insoluble in cold water, alcohol, ether, and oils, and in being converted into sugar by either dilute sulphuric acid or diastase. The main difference between them consists in their habitudes with water and iodine. The first forms with hot water a mucilaginous solution, which constitutes, when cold, the paste of the laundress, and is tinged blue by iodine; the second forms a granular precipitate, when its solution in boiling hot water is suffered to cool, which is tinged yellow by iodine; the third affords, by cooling the concentrated solution, a gelatinous mass, with a clear liquor floating over it, that contains little starch. Its jelly becomes brown-gray with iodine.

1. *Ordinary starch.* — This may be extracted from the following grains:—wheat, rye, barley, oats, buckwheat, rice, maize, millet, spelt; from the siliquose seeds, as peas, beans, lentiles, &c.; from tuberous and tap roots, as those of the potato, the orchis, manioc, arrow-root, batata, &c. Different kinds of corn yield very variable quantities of starch. Wheat differs in this respect, according to the varieties of the plant, as well as the soil, manure, season, and climate.*

2. *With unground wheat.*—The wheat being sifted clean, is to be put into cisterns, covered with soft water, and left to steep till it becomes swollen and so soft as to be easily crushed between the fingers. It is now to be taken out, and immersed in clear water of a temperature equal to that of malting-barley, whence it is to be transferred into bags, which are placed in a wooden chest containing some water, and exposed to strong pressure. The water rendered milky by the starch being drawn off by a tap, fresh water is poured in, and the pressure is repeated. Instead of putting the swollen grain into bags, some prefer to grind it under vertical edge-stones, or between a pair of horizontal rollers, and then to lay it in a cistern, and separate the starchy liquor by elutriation with successive quantities of water well stirred up with it. The residuary matter in the sacks or cisterns contains much vegetable albumen and gluten, along with the husks; when exposed to fermentation, it affords a small quantity of starch of rather inferior quality.

The above milky liquor, obtained by expression or elutriation, is run into large cisterns, where it deposites its starch in layers successively less and less dense; the uppermost containing a considerable proportion of gluten. The supernatant liquor being drawn off, and fresh water poured on it, the whole must be well stirred up, allowed again to settle, and the surface-liquor again withdrawn. This washing should be repeated as

* Wheat partly damaged by long keeping in granaries, may be employed for the manufacture of starch, as this constituent suffers less injury than the gluten; and it may be used either in the ground or unground state.

long as the water takes any perceptible color. As the first turbid liquor contains a mixture of gluten, sugar, gum, albumen, &c., it ferments readily, and produces a certain portion of vinegar, which helps to dissolve out the rest of the mingled gluten, and thus to bleach the starch. It is, in fact, by the action of this fermented or soured water, and repeated washing, that it is purified. After the last deposition and decantation, there appears on the surface of the starch a thin layer of a slimy mixture of gluten and albumen, which, being scraped off, serves for feeding pigs or oxen; underneath will be found a starch of good quality. The layers of different sorts are then taken up with a wooden shovel, transferred into separate cisterns, where they are agitated with water, and passed through fine sieves. After this pap is once more well settled, the clear water is drawn off, the starchy mass is taken out, and laid on linen cloths in wicker baskets, to drain and become partially dry. When sufficiently firm, it is cut into pieces, which are spread upon other cloths, and thoroughly desiccated in a proper drying room, which in winter is heated by stoves. The upper surface of the starch is generally scraped, to remove any dusty matter, and the resulting powder is sold in that state. Wheat yields, upon an average, only from 35 to 40 per cent. of good starch. It should afford more by skilful management.

M. Leroy, of Brussels, has found that water is requisite to the production of the blue color which arises from the action of iodine on starch: in alcohol the iodine becomes merely of a dark brown color, and water causes the blue color to appear. M. Chevalier has also remarked that farinaceous substances mixed with starch, which are always moist, when subjected to the vapor of iodide, acquired a brown (blue?) color, while potato starch became of a golden yellow merely. He concluded, from this circumstance, that iodine of starch is of a yellow color, and that this by absorbing (and combining with) water became blue hydrate; and he found that when this yellow compound was touched with a moistened tube, it became instantly blue.

M. Lassaigne remarks, that in making some experiments on the combination of iodine with amidine (starch altered by heat), which is easily obtained by gradually pouring an alcoholic solution of iodine into the solution obtained from the starch extracted cold from bruised grain, he found its fine deep indigo blue color gradually disappear by the action of heat, and at a temperature of about 175° to 195° of Fahr. it entirely disappeared, the fluid remaining transparent. It was at first supposed that the iodide of amidine had been decomposed by the heat; but this was not the case, for, on cooling, the blue color gradually reappeared, and eventually became as dark as at first. This experiment of the alternate destruction and reproduction of color may be several times repeated, provided the heat be not continued longer than is required to decolorize the liquor; and a few minutes boiling beyond this point destroys

the power of reproduction. In this, however, it did not appear that the iodine was volatilized by the vapor of water, as might be supposed; for it is found, in part, in the decolorized liquor in the state of hydriodic acid, mixed with a portion of undecomposed amidine; and the addition of a few drops of a weak solution of chlorine explains why the blue color is reproduced by this chemical agent.

STEATITE, is a mineral of the magnesian family. It has a grayish-white or greenish-white color, often marked with dendritic delineations, and occurs massive, as also in various supposititious crystaline forms; it has a dull or fatty lustre; a coarse splintery fracture, with translucent edges; a shining streak; it writes feebly; is soft, and easily cut with a knife; but somewhat tough; does not adhere to the tongue; feels very greasy; infusible before the blowpipe; specific gravity from 2·6 to 2·8. It consists of—silica, 44; magnesia, 44; alumina, 2; iron, 7·3; manganese, 1·5; chrome, 2; with a trace of lime. It is found frequently in small contemporaneous veins that traverse serpentine in all directions, as at Portsoy, in Shetland, in the limestone of Icolmkiln, in the serpentine of Cornwall, in Anglesey, in Saxony, Bavaria, (at Bayruth,) Hungary, &c. It is used in the manufacture of porcelain. It makes the biscuit semi-transparent, but rather brittle, and apt to crack with slight changes of heat. It is employed for polishing serpentine, marble, gypseous alabaster, and mirror glass; as the basis of cosmetic powders; as an ingredient in anti-attrition pastes; it is dusted in powder upon the inside of boots, to make the feet glide easily into them; when rubbed upon grease-spots in silk and woolen cloths, it removes the stains by absorption;* it enters into the composition of certain crayons, and is used itself for making traces upon glass, silk, &c.†

SUBLIMATION, is the process by which the volatile particles are raised by heat, and condensed into a crystaline mass.‡ This operation is frequently resorted to for the purpose of purifying various chemical products, and separating them from substances which are less volatile.

SUBSALT, is a salt in which the base is not saturated with acid; as subacetate of lead.

SULPHATES, are saline compounds of sulphuric acid with oxidized bases.§ The minutest quantity of them present in any solution, may be detected by the precipitate, insoluble in nitric or muriatic acid, which they afford with nitrate or muriate of baryta. They are mostly insoluble in alcohol.

SULPHATE OF ALUMINA AND POTASSA, is alum.

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* See chapter IV., Part V.

† The spotted steatite, cut into cameos and calcined, assumes an onyx aspect. Soft steatite forms excellent stoppers for the chemical apparatus used in distilling or subliming corrosive vapors. Lamellar steatite is *Talc*.

‡ For an example, see *Sal Ammoniac*.

§ Green vitriol is a *sulphate* of the protoxide of iron. Glauber's salt is a *sulphate* of soda.

SULPHATE OF AMMONIA, is a salt sometimes formed by saturating the ammonia liquor of the gas-works with sulphuric acid; and it is employed for making carbonate of ammonia.—(See *Ammonia* and *Sal Ammoniac.)*

SULPHATE OF COPPER, or *Blue Vitriol*, similar to the artificial salt of the laboratory. The blue water which flows from certain copper mines is a solution of this salt. The copper is easily procured in the metallic state by plunging pieces of iron into it.

SULPHATE OF IRON.—M. Berthemot, (I. de Phar.) offers the following observations on "preparing the sulphate of iron so as to preserve it at a *minimum* of oxidation."—Having dissolved and crystalized in water sharpened with sulphuric acid, a portion of common sulphate of iron, exempt from copper and zinc, take 500 parts of it and dissolve it in 550 parts of distilled water: then add to the solution 8 parts of pure iron turnings, and after a few minutes filter it boiling hot, taking care to moisten the filter previously, that the liquid may flow through it more rapidly. Put the solution in a vessel containing 375 parts of alcohol at 33° to 36°, and 8 parts of sulphuric acid, stirring it briskly with a glass rod as it is poured in. The sulphate of iron immediately precipitates in the form of a bluish white crystaline powder, and thus prepared it will remain in the air without the least alteration. It contains, besides, the same proportion of water of crystalization as that which is deposited from an aqueous solution. It is only after boiling it for some time in strong alcohol that it gives up a portion.—(See chapters I. and III., Part III.)

SULPHATE OF LEAD.—(See *Calico Printing.*)

SULPHATE OF MAGNESIA, *Epsom salt*, exists in sea-water, as also in the waters of Saidschütz, Seidlitz and Püllna; and in many saline springs, besides Epsom in Surrey, whence it has derived its trivial name, and from which it was first extracted, in the year 1695, and continued to be so, till modern chemistry pointed out cheaper and more abundant sources of this useful purgative salt. The sulphate of magnesia, occasionally found effloresced on the surface of minerals in crystaline filaments, was called *haarsalz* (hair salt) by the older writers. The bittern of the Scotch sea-salt works is muriate of magnesia, mixed with a little sulphate of magnesia and chloride of sodium. If the proper decomposing quantity (found by trial) of sulphate of soda be added to it, and the mixed solution be evaporated at the temperature of 122° F., chloride of sodium will form by double affinity, and fall down in cubical crystals; while the solution of sulphate of magnesia, which remains, being evaporated to the proper point, will afford regular crystals in four-sided prisms with four-sided acuminations. Or, if bittern be treated in a retort with the equivalent quantity of sulphuric acid, the muriatic acid may be distilled off into a series of Woulfe's bottles and the sulphate of magnesia, soda, and lime, will remain in the retort, from which mixture

the sulphate of magnesia may be separated by filtration and crystalization.

Magnesian limestone being digested, with as much muriatic acid as will dissolve out its lime only, will, after washing, afford, with the equivalent quantity of sulphuric acid, a pure sulphate of magnesia; and this is certainly the simplest and most profitable process for manufacturing this salt upon the great scale. Many prepare it directly, by digesting upon magnesian limestone the equivalent saturating quantity of dilute sulphuric acid. The sulphate of lime being separated by subsidence, the supernatant solution of sulphate of magnesia is evaporated and crystalized.

This salt is composed of, magnesia 16·72, sulphuric acid 32·39, and water 50·89. When free from muriate, it tends to effloresce in the air. It dissolves in 4 parts of water at 32°, in 3 parts at 60°, in 1·4 at 200°, and in its own water of crystalization at a higher heat.

SULPHATE OF MANGANESE is prepared on the great scale for the calico-printers, by exposing the peroxide of the metal and pitcoal ground together, and made into a paste with sulphuric acid, to a heat of 400° F. On lixiviating the calcined mass, a solution of the salt is obtained, which is to be evaporated and crystalized. It forms pale amethyst-colored prisms, which have an astringent bitter taste, dissolve in 2½ parts of water, and consist of, protoxide of manganese 31·93, sulphuric acid 35·87, and water 32·20, in 100 parts.

SULPHATE OF MERCURY is a white salt which is used in making corrosive sublimate.—(See *Corrosive Sublimate.*)

SULPHATE OF POTASH.—This salt may readily be prepared by decomposing carbonate of potash by sulphuric acid. It is produced on a large scale in the manufacture of nitric acid, of which it constitutes the residue. Its taste is saline and bitter; it crystalizes in six-sided prisms, which contain no water of crystalization, and suffer no change by exposure to air. It is not very soluble, and requires sixteen times its weight of cold water and five of boiling water for its solution. It decrepitates at a red heat, and is volatilized, without decomposition, at a still higher temperature. If hydrogen gas be passed over it at a red heat it will be decomposed; the oxygen both of the acid and base will be abstracted, and sulphuret of potassium remain. It also produces sulphuret of potassium by calcination, at a high heat, with one-fifth of its weight of charcoal. When two parts of this salt and one of lampblack are heated to redness in a phial coated with clay, and the air carefully excluded during the process, a powder is obtained which takes fire upon exposure to the air; a phenomenon owing to the heat evolved by the rapid absorption of oxygen and the consequent ignition of the sulphur and charcoal.

SULPHATE OF SODA.—The sulphate of soda may be formed by the direct combination of the acid and base, but is abundantly produced

in the manufacture of muriatic acid by the decomposition of common salt. It crystalizes, from its aqueous solution, in four-sided prisms, which contain ten equivalents of water of crystalization. Of these it parts with a very large proportion by efflorescence in a dry atmosphere. Its taste is saline and bitter, and it has been long known in medicine by the name of *Glauber's Salt*. It is very soluble in water, but presents a very singular irregularity in this respect. Its solubility increases to a certain point, and then diminishes. It increases to 92°, which is the maximum point, and decreases to 215°. It is insoluble in alcohol. It may be deprived of its water of crystalization by heat, and then resists further decomposition. The taste of the anhydrous salt is acrid and hot, and it absorbs moisture with great avidity. It may be made, consecutively, to undergo both the aqueous and igneous fusion.

A bisulphate of soda may be formed by a similar process to that by which the analogous salt of potash is produced.

SULPHATE OF ZINC, called also *White Vitriol*, is commonly prepared in the Hearz, by washing the calcined and effloresced sulphuret of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphurets of iron and copper. Pure sulphate of zinc may be made most readily by dissolving the metal in dilute sulphuric acid, evaporating and crystalizing the solution. It forms prismatic crystals, which have an astringent, disagreeable, metallic taste; they effloresce in a dry air, dissolve in 2·3 parts of water at 60°, and consist of—oxide of zinc, 28·29; acid, 28·18; water, 43·53. Sulphate of zinc is used for preparing drying oils for varnishes, and in the reserve or resist pastes of the calico-printer.

SULPHITES are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxidized bases.

SULPHUR.—Sulphur is one of the few elements which occur in nature in their simple form. It is a well known mineral substance, found in large quantities in the neighborhood of volcanoes; and, as an article of commerce, is chiefly brought from the Mediterranean. It is commonly met with in two forms—that of a compact, brittle solid; and that of a fine powder. It is of a light yellow color; and when melted emits a peculiar odor. It is insoluble in water, and tasteless. It is about double the weight of water, its specific gravity being 1·98. It is readily melted and volatilized, and begins to evaporate at 170°, and to fuse at 105°. At 220° it becomes completely fluid; but possesses the peculiar property of solidifying at a higher degree, or at 350°, and of again melting by a reduction of temperature. It sublimes (this term is used to denote the evaporation of a solid) at 600°; and condenses into the form of a powder, or, as it is termed, of *flowers*. When poured into water, in the state of complete fusion, it becomes of the consistency of wax, and assumes a red

color; it may then be used for taking impressions from engraved stones, and hardens upon cooling.

Sulphur is completely soluble in boiling oil of turpentine, and in alcohol, when the two substances are brought in contact in the state of vapor. It is inflammable; that is to say, it combines, when ignited, with the oxygen of the atmosphere, with the evolution of light and heat. It burns with a faint blue light, at the temperature of about 180° or 190°; and the evolution of heat is so small, that it may be burned out of gunpowder, of which it is one of the principal ingredients, without inflaming it. At a temperature of 300°, however, its combustion is more rapid. It is not affected by air or water.

SULPHURATION, is the process by which woolen, silk, and cotton goods are exposed to the vapors of burning sulphur, or to sulphurous acid gas.—(See chapter IV., Part II.)

T.

TANNIN, *artificial*.—By digesting powdered charcoal in nitric acid, and carefully evaporating the solution so obtained, Mr. Hatchett succeeded in procuring a brown substance of an astringent taste, and precipitating solution of gelatine, which he therefore terms *artificial tan*.—(See *Tannin* and *Gallic Acid*, chapter II., Part III.)

TARTAR, called also argal or argol, is the crude bitartrate of potassa, which exists in the juice of the grape, and is deposited from wines in their fermenting casks, being precipitated in proportion as the alcohol is formed, in consequence of its insolubility in that liquid. There are two sorts of argal known in commerce, the white, and the red; the former, which is of a pale-pinkish color, is the crust let fall by white wines; the latter is a dark-red, from red wines.

The crude tartar is purified, or converted into cream of tartar, at Montpellier, by the following process:—

The argal having been ground under vertical mill-stones, and sifted, one part of it is boiled with 15 of water in conical copper kettles, tinned on the inside. As soon as it is dissolved, 3½ parts of ground pipe-clay are introduced. The solution being well stirred, and then settled, is drawn off into crystalizing vessels to cool; the crystals found concreted on the sides and bottom are picked out, washed with water and dried. The mother water is employed upon a fresh portion of argal. The crystals of the first crop are re-dissolved, re-crystallized, and exposed upon stretched canvass to the sun and air, to be bleached. The clay serves to abstract the coloring matter. The crystals formed upon the surface are the whitest, whence the name cream of tartar is derived.

Purified tartar, the bitartrate of potassa, is thus obtained in hard clusters of small colorless crystals, which, examined by a lens, are seen to be transparent 4-sided prisms. It has no smell, but a feebly acid taste; is unchangeable in the air, has a specific gravity of 1·953, dissolves in 16

parts of boiling water, and in 200 parts at 60° F. It is insoluble in alcohol. It consists of 24·956 potassa, 70·276 tartaric acid, and 4·768 water. It affords, by dry distillation, pyrotartaric acid, and an empyreumatic oil; while carbonate of potassia remains associated with much charcoal in the retort, constituting a black flux. Tartar is extensively, as has been shown, used in dyeing.

TARTRATE OF POTASH.—Tartrate of potash is a salt which crystalizes in large transparent four-sided right prisms with rectangular bases. They contain two atoms of water of crystalization, but are easily rendered anhydrous by heat. A quantity of these crystals was left upon the sand bath for twenty-four hours in a covered glass capsule, in a heat amounting for several hours to about 240°; 14·25 grains of the salt, thus rendered anhydrous, were dissolved in distilled water; 20·75 grains of dry nitrate of lead were dissolved in another portion of distilled water, and the two liquids were mixed together: a double decomposition took place, and the tartrate of lead precipitated with such rapidity that in about an hour it left the mother water quite transparent and colorless. This mother water was tested with nitrate of lead and tartrate of potash, without being in the least affected by either. Hence, it contained no sensible quantity either of tartaric acid or of lead. The whole of these two bodies was contained in the precipitate which had fallen.

THERMOMETER, *Fahrenheit's.*—In this thermometer the freezing point of water is placed at 32°, and the boiling point at 212°.

In *Reamur's thermometer* the freezing point is at zero, and the boiling point at 80°. From this it is evident that 180 degrees of Fahrenheit are equal to 80° of Reamur; or 1 degree of Fahrenheit is equal to $\frac{4}{9}$ths of a degree of Reamur. It is easy, therefore, to convert the degrees of one into the equivalent numbers of the other; but upon ascertaining the corresponding point upon the different scales, it is necessary to take into consideration their different modes of graduation. Thus, as the zero of Fahrenheit is 32° below the point at which that of Reamur is placed, this number must be taken into the calculation. If, for example, any degree of *Reamur* above or below zero be multiplied by 9 and divided by 4, the quotient will be the number of degrees above or below 32° or the freezing point of *Fahrenheit.**—(See *Areometer;* also *Ebullition.*)

TIN MORDANTS.—"Several preparations of tin are employed as mordants in dyeing and calico-printing, comprising salts of the protoxide and of the peroxide, and mixtures of the salts of both oxides. The oxides of tin have a strong tendency to unite with soluble vegetable and animal coloring matters, producing distinct and definite combinations; and the compounds with the peroxide are generally distinguished for possessing a

* "United States Dispensatory," p. 1326. Philadelphia: Grigg & Elliot. 1843.

vivacity of teint far superior to that presented by the combinations of the same coloring matter with any other mordant.

"*Peroxide of tin* is used as a mordant chiefly with cochineal, Brazil-wood, peachwood, barwood, French berries, and logwood, and is commonly applied in a state of a solution of the perchloride (permuriate), or as a mixture of the solution of the perchloride with that of the pernitrate. Such solutions, which are known among dyers by the name of *red spirits* or simply *spirits*, may be obtained by dissolving metallic tin, in a granulated or "feathered" state, in one of the following liquids :—

1. Aqua regia, which is a mixture of nitric and muriatic acids;
2. A mixture of nitric acid and muriate of ammonia; and
3. A mixture of nitric acid, muriate of ammonia, and common salt.

"The perchloride of tin, or a mixture of the perchloride and pernitrate, is also sometimes prepared from crystals of the protochloride (salts of tin) by means of nitric acid or aqua regia. The nitric acid used for this purpose should be quite free from sulphuric acid.

"A great number of receipts for the preparation of this mordant have been prescribed, varying very considerably in the proportions of the materials, according to the nature of the fabric to be dyed, and that of the dye-stuff for which it is to be used as the mordant. Some of the preparations contain the peroxide or perchloride only; but others, which are preferred for general use, contain both the perchloride and the protochloride. A common process for preparing a mixture of the two chlorides is to add granulated tin very gradually to a mixture of three parts by measure of muriatic acid, and one part of commercial nitric acid, so long as any tin is dissolved in the cold. If the tin is not added gradually, instead of being dissolved, it is converted into the insoluble peroxide, which is deposited as a white powder.

"The above proportions answer well for a mordant for general use, and especially for Brazil-wood; but for particular purposes the proportions of muriatic and nitric acids are varied from six parts of the former, and one of the latter, to equal parts.

"The solution of the perchloride of tin, or mixed perchloride and protochloride made by dissolving tin in a mixture of nitric acid and sal-ammoniac, is much used by silk and woolen dyers, but a considerable difference exists between the proportions of the materials as recommended by different dyers. For general purposes, the solution afforded by the following proportions receives a decided preference :—

3 quarts of nitric acid of specific gravity 1·300,
4 quarts of water,
12 ounces of muriate of ammonia,
30 ounces of granulated tin.

"The muriate of ammonia is first dissolved in the mixture of acid and

water, and to this solution the tin is added in small quantities at a time, so as to prevent the mixture from becoming very hot.

"The salt met with in commerce under the name of *pink salt* is the double perchloride of tin and muriate of ammonia (chloride of tin and ammonium), which is made by adding muriate of ammonia to a solution of the perchloride, and evaporating to obtain crystals. It is chiefly used as a mordant with peach-wood.

"Peroxide of tin is often applied to cloth in the state of the soluble combination of caustic potash and oxide of tin, known as stannate of potash, which may be obtained by adding a solution of caustic potash to a solution of perchloride of tin, until the precipitate at first produced is entirely redissolved. If a piece of cotton impregnated with such a solution is dipped into dilute sulphuric acid, or a solution of muriate of ammonia, the alkaline combination on the cloth is decomposed, and peroxide of tin precipitated within the fibre. The decomposition which ensues on mixing stannate of potash with muriate of ammonia is quite analogous to that which occurs on the mixture of aluminate of potash with muriate of ammonia.

"*Protoxide of tin* is frequently used as a mordant alone, as well as the peroxide. This oxide may be applied from the protochloride of tin. which is prepared by dissolving metallic tin in pure muriatic acid to saturation, with the assistance of heat. One part of tin may be dis solved in about three parts of concentrated muriatic acid, and on evapo ration the solution affords small colorless crystals, distinguished as *salts of tin*. The solution of the protochloride is known among dyers by the name of *plum spirits*, being used in the preparation of the *plum tub*, which is a mixture of decoction of logwood with the protochloride.

"This salt has several interesting applications in calico-printing, both as a mordant and a deoxidizing agent. The solution of protoxide of tin in a caustic alkali, obtained by adding the alkali to the solution of protochloride of tin until the protoxide at first precipitated is redissolved, is frequently used in the place of the protochloride.

"When exposed to the air, a solution of protochloride of tin absorbs oxygen, and affords, if not very acid, a white precipitate consisting of a subsalt of the peroxide. This inconvenience may be counteracted to a great extent by the addition of muriate of ammonia, which combines with the protochloride to form a double salt, less disposed to absorb oxygen than the pure protochloride.

"The colors of the compounds of coloring matters with peroxide of tin are generally much brighter than those of the same compounds with protoxide of tin, but solutions of the protoxide enter the pores of cotton fabrics better than solutions of the peroxide. On this account, a practice sometimes pursued in dyeing cotton goods by a tin mordant, is first to apply the tin in the state of protochloride, and to form the peroxide af-

terward, within the fibre, by wincing the goods in a dilute solution of chloride of lime."*—(See chapter I., Part III., article *Tin*, and chapter I., Part VI.)

TROY WEIGHT.—An English weight chiefly used in weighing gold, silver, diamonds, and other articles of jewelry. The pound troy contains 12 ounces or 5760 grains, the pound avoirdupois containing 7000 of such grains. The name is supposed to have reference to the monkish name given to London, of Troy Novant.—(See *Weight.*)

TURPENTINE, OIL OF.—(See *Oil of Turpentine.*)

U.

ULTRAMARINE, is a beautiful blue pigment obtained from the variegated blue mineral, called lazulite (*lapis lazuli*), by the following process:—

Grind the stone to fragments, rejecting all the colorless bits, calcine at a red heat, quench in water, and then grind to an impalpable powder along with water, in a paint-mill, or with a porphyry slab and muller. The paste, being dried, is to be rubbed to powder, and passed through a silk sieve. 100 parts of it are to be mixed with 40 of rosin, 20 of white wax, 25 of linseed oil, and 15 of Burgundy pitch, previously melted together. This resinous compound is to be poured hot into cold water; kneaded well first with two spatulas, then with the hands, and then formed into one or more small rolls.

MM. Clement and Desormes, who were the first to divine the true nature of this pigment, think that the soda contained in the lazulite, uniting with the oil and the rosin, forms a species of soap, which serves to wash out the coloring matter. If it should not separate readily, water heated to about 150° F. should be had recourse to. When the water is sufficiently charged with blue color, it is poured off and replaced by fresh water; and the kneading and change of water are repeated till the whole of the color is extracted. Others knead the mixed resinous mass under a slender stream of water, which runs off with the color into a large earthen pan. The first waters afford, by rest, a deposite of the finest ultramarine; the second, a somewhat inferior article, and so on. Each must be washed afterwards with several more waters, before they acquire the highest quality of tone; then dried separately, and freed from any adhering particles of the pitchy compound by digestion in alcohol. The remainder of the mass being melted with oil, and kneaded in water containing a little soda or potash, yields an inferior pigment, called *ultramarine ashes*. The best *ultramarine* is a splendid blue pigment, which works well with oil, and is not liable to change by time. Its price in Italy was *twenty-five dollars the ounce*, a few years ago, but it is now greatly reduced.

* Applied Chemistry, p. 116.

The blue color of *lazulite* had been always ascribed to iron, till MM. Clement and Desormes, by a most careful analysis, showed it to consist of—silica, 34; alumina, 33; sulphur, 3; soda, 22; and that the iron, carbonate of lime, &c., were accidental ingredients, essential neither to the mineral, nor to the pigment made from it. By another analyst, the constituents are said to be—silica, 44; alumina 35; and soda, 21; and by a third, potassa was found instead of soda, showing shades of difference in the composition of the stone.

Till a few years ago, every attempt failed to make ultramarine artificially. At length, in 1828, M. Guimet resolved the problem, guided by the analysis of MM. Clement and Desormes, and by an observation of M. Tassaert, that a blue substance like ultramarine was occasionally produced on the sandstone hearths of his reverberatory soda furnaces. "Of M. Guimet's finest pigment I received," says Dr. Ure, "a bottle several years ago, from my friend M. Merimée, Secretary of the *Ecole de Beaux Arts*, which has been found by artists little, if any, inferior to the lazulite ultramarine." M. Guimet sells it at *sixty francs per pound French*,—which is little more than *two guineas the English pound*. He has kept his process secret. But M. Gmelin, of Tübingen, has published a prescription for making it; *which consists in enclosing carefully in a Hessian crucible a mixture of two parts of sulphur, and one of dry carbonate of soda, heating them gradually to redness till the mass fuses, and then sprinkling into it by degrees another mixture, of silicate of soda, and aluminate of soda; the first containing seventy-two parts of silica, and the second seventy parts of alumina.* The crucible must be exposed after this for an hour to the fire. The ultramarine will be formed by this time; only it contains a little sulphur, which can be separated by means of water. M. Persoz, professor of chemistry at Strasburg, has likewise succeeded in making an ultramarine, of perhaps still better quality than that of M. Guimet. Lastly, M. Robiquet has announced, that it is easy to form ultramarine, by heating to redness a proper mixture of kaolin (China clay), sulphur, and carbonate of soda. It would therefore appear, from the preceding details, that ultramarine may be regarded as a compound of silicate of alumina, silicate of soda, with sulphuret of sodium; and that to the reaction of the last constituent upon the former two, it owes its color.—(See *Lazulite*.)

V.

VAPOR, is the state of elastic or aëriform fluidity into which any substance, naturally solid or liquid at ordinary temperatures, may be converted by the agency of heat.

VERDIGRIS is a mixture of the crystalized acetate of copper and

the subacetate, in varying proportions. According to Vauquelin's researches, there are three compounds of oxide of copper and acetic acid; 1. a subacetate, insoluble in water, but decomposing in that fluid, at common temperatures changing into peroxide and acetate; 2. a neutral acetate, the solution of which is not altered at common temperatures, but is decomposed by ebullition, becoming peroxide and superacetate; and, 3. superacetate, which in solution is not decomposed, either at common temperatures or at the boiling point; and which cannot be obtained in crystals, except by slow spontaneous evaporation, in air or *in vacuo*. The first salt, in the dry state, contains 66·51 of oxide; the second, 44·44; and the third, 33·34.

Mr. Phillips has given the following analysis of French and English verdigris; *Annals of Philosophy*, No. 21.—

	French Verdigris.	English Verdigris.
Acetic acid - -	29·3	29·62
Peroxide of copper	43·5	44·25
Water - - -	25·2	25·51
Impurity - -	2·0	0·62
	100·0	100·00

Distilled verdigris, as it was long erroneously called, is merely a *binacetate* or superacetate of copper, made by dissolving, in a copper kettle, one part of verdigris in two of distilled vinegar, aiding the mutual action by slight heat and agitation with a wooden spatula. When the liquor has taken its utmost depth of color, it is allowed to settle, and the clear portion is decanted off into well-glazed earthen vessels. Fresh vinegar is poured on the residuum, and if its color does not become deep enough, more verdigris is added. The clear and saturated solution is then slowly evaporated, in a vessel kept uniformly filled, till it acquires the consistence of sirup, and shows a pellicle on its surface; when it is transferred into glazed earthen pans, called *oulas* in the country. In each of these dishes, two or three sticks are placed, about a foot long, cleft till within two inches of their upper end, and having the base of the cleft kept asunder by a bit of wood. This kind of pyramid is suspended by its summit in the liquid. All these vessels are transported into crystalizing rooms, moderately heated with a stove, and left in the same state for 15 days, taking care to maintain a uniform temperature. Thus are obtained very fine groups of crystals of acetate of copper, clustered round the wooden rods; on which they are dried, taken off, and sent into the market. They are distinctly rhomboidal in form, and of a lively deep blue color. Each cluster of crystals weighs from five to six pounds; and, in general their total weight is equal to about one third of the verdigris employed.

The crystalized binacetate of commerce consists, by Dr. Ure's anal-

ysis, of acetic acid, 52; oxide of copper, 39·6; water, 8·4, in 100. He says that he prepared crystals which contained no water. There is a triple acetate of copper and lime, which resembles distilled verdigris in color. It was manufactured pretty extensively in Scotland some years ago, and brought a high price, till an analysis of it was published in the Edinburgh Philosophical Journal. It is much inferior, for all uses in the arts, to the proper binacetate.

The copper used in this manufacture is formed into round sheets, from 20 to 25 inches in diameter, by one twenty-fourth of an inch in thickness. Each sheet is then divided into oblong squares, from 4 to 6 inches in length, by 3 broad; and weighing about 4 ounces. They are separately beaten upon an anvil, to smoothe their surfaces, to consolidate the metal, and to free it from scales. The refuse of the grapes, after the extraction of their juice, formerly thrown on the dunghill, is now preserved for the purpose of making verdigris. It is put loosely into earthen vessels, which are usually 16 inches high, 14 in diameter at the widest part, and about 12 at the mouth. The vessels are then covered with lids, which are surrounded with straw mats. In this situation the materials soon become heated, and exhale an acid odor; the fermentation beginning at the bottom of the cask, and gradually rising till it actuate the whole mass. At the end of two or three days, the manufacturer removes the fermenting materials into other vessels, in order to check the process, lest putrefaction should ensue. The copper plates, if new, are now prepared, by rubbing them over with a linen cloth dipped in a solution of verdigris; and they are laid up alongside of one another to dry. If the plates are not subjected to this kind of preparation, they will become black, instead of green, by the first operation. When the plates are ready, and the materials in a fermenting state, one of them is put into the earthen vessel for 24 hours, in order to ascertain whether it be a proper period to proceed to the remaining part of the process. If, at the end of this period, the plate be covered with a uniform green layer, concealing the whole copper, everything is right; but if, on the contrary, liquid drops hang on the surface of the metal, the workmen say the plates are *sweating*, and conclude that the heat of the fermented mass has been inadequate; on which account another day is allowed to pass before making a similar trial. When the materials are finally found to be ready, the strata are formed in the following manner. The plates are laid on a horizontal wooden grating, fixed in the middle of a vat, on whose bottom a pan full of burning charcoal is placed, which heats them to such a degree, that the women who manage this work are obliged to lay hold of them frequently with a cloth when they lift them out. They are in this state put into earthen vessels, in alternate strata with the fermented materials, the uppermost and undermost layers being composed of the expressed grapes.

The vessels are covered with their straw mats, and left at rest. From 30 to 40 pounds of copper are put into one vessel.

At the end of 10, 12, 15, or 20 days, the vessels are opened, to ascertain, by the materials having become white, if the operation be completed.

Detached glossy crystals will be perceived on the surface of the plates; in which case the grapes are thrown away, and the plates are placed upright in a corner of the verdigris cellar, one against the other, upon pieces of wood laid on the ground. At the end of two or three days they are moistened by dipping in a vessel of water, after which they are replaced in their former situation, where they remain seven or eight days, and are then subjected to momentary immersion, as before. This alternate moistening and exposure to air is performed six or eight times, at regular intervals of about a week. As these plates are sometimes dipped into damaged wine, the workmen term these immersions, *one wine, two wines*, &c.

By this treatment, the plates swell, become green, and covered with a stratum of verdigris, which is readily scraped off with a knife. At each operation every vessel yields from five to six pounds of verdigris, in a *fresh* or *humid* state; which is sold to wholesale dealers, who dry it for exportation. For this purpose, they knead the paste in wooden troughs, and then transfer it to leathern bags, a foot and a half long, and ten inches in diameter. These bags are exposed to the sun and air, till the verdigris has attained a sufficient degree of hardness. It loses about half its weight in this operation; and it is said to be knife-proof, when this instrument, plunged through the leathern bag, cannot penetrate the loaf of verdigris.

VERMILION, or *Cinnabar*, is a compound of mercury and sulphur, in the proportion of 100 parts of the former to 16 of the latter, which occurs in nature as a common ore of quicksilver, and is prepared by the chemist as a pigment, under the name of Vermilion. It is, properly speaking, a bisulphuret of mercury. This artificial compound being extensively employed, on account of the beauty of its color, in painting, for making red sealing-wax, and other purposes, is the object of an important manufacture. When vermilion is prepared by means of sublimation, it concretes in masses of considerable thickness, concave on one side, convex on the other, of a needle-form texture; brownish-red in the lump, but when reduced to powder, of a lively red color. On exposure to a moderate heat, it evaporates without leaving a residuum, if it be not contaminated with red lead; and at a higher heat it takes fire, and burns entirely away, with a blue flame.—(See *Cinnabar*.)

W.

WATER OF CRYSTALIZATION.—Some crystalized salts contain more or less water, which, as it bears a definite proportion to the other components of the salt, may be considered as one of its essential constituents. Crystalized sulphate of lime, for instance, is a compound of 68 of dry sulphate and 18 water, or of 1 equivalent of anhydrous salt and 2 equivalents of water; 1 equivalent of crystalized sulphate of magnesia = 123, contains 7 of water = 63; and an equivalent of crystalized sulphate of soda = 162, contains 10 of water = 90; the equivalent of water being 9. But it does not necessarily follow that a salt in crystals contains water, there being many crystals which are *anhydrous*, such as nitre, sulphate of potash, &c.—(See *Crystalization.*)

WEIGHT.—In mechanics,* denotes the resistance to be overcome by a machine, whether in raising, or sustaining, or moving a heavy body. The force applied to the machine for this purpose is called the moving power; and where the equilibrium subsists, the difference between the weight and the moving power is the purchase of the machine. In all cases of equilibrium by the intervention of machinery, if the machine be put in motion by a small additional force, the space passed over by the moving power will be greater than that passed over by the weight, in proportion as the weight is greater than the moving power; or the product of the weight by its velocity will be equal to the product of the moving power by its velocity.

Tables of British Weights.

1. *Imperial Troy Weight.*—Standard: one cubic inch of distilled water, at 62° Fahrenheit's thermometer, the barometer being 30 inches, weighs 252·458 troy grains.

grs.	dwts.		
24 =	1	oz	
480 =	20 =	1	lb.
5760 =	240 =	12 =	1

Troy weight is used in weighing gold, silver, jewels, &c., and in philosophical experiments.

* Weight, in physics, that property in bodies in virtue of which they tend towards the centre of the earth. In this sense, weight is synonymous with gravity. When a body is carried below the surface of the earth, its weight becomes less, because the matter then above it is drawing it up, instead of down, as before. A descent of a few hundred feet makes a sensible difference, and at the centre of the earth, if a man could reach it, he would find things to have no weight at all; and there would be neither up nor down, because bodies would be attracted equally in all directions.

2. *Apothecaries' Weight.*—Standard: the same as in troy weight, with the ounce divided into 8 drachms and 24 scruples.

grs.	scrs. (℈)	drs. (ʒ)	oz. (℥)	lb. (℔)
20 =	1			
60 =	3 =	1		
480 =	24 =	8	1	
5760 =	288 =	96 =	12 =	1

Medicines are compounded by this weight; but drugs are usually bought and sold by avoirdupois weight.

3. *Imperial Avoirdupois Weight.*—Standard: the same as in troy weight; and one avoirdupois pound = 7000 troy grains.

drs.	oz.	lbs.	qrs.	cwts.	ton.
16 =	1				
256 =	16 =	1			
7168 =	448 =	28 =	1		
28672 =	1792 =	112 =	4 =	1	
573440 =	35840 =	2240 =	80 =	20 =	1

This weight is used for the general purposes of commerce.

The preceding are the British statute weights; but numerous other discordant denominations of weight, generally multiples of the avoirdupois pound, are still used in different parts of the country for weighing particular kinds of merchandise. One of the most common of these is the *stone*, which has a great variety of different significations. In London, however, only two stones are generally understood; viz., the stone of 8 pounds for butchers' meat, and the stone of 14 pounds for other commodities. A particular denomination of weight, a *carat*, is used for weighing diamonds. An ounce troy is equivalent to 151½ carats; consequently a carat is nearly equal to 3⅛ grains. In expressing the fineness of gold by *carats*, the term rather denotes a proportion than a weight. Thus gold 22 carats fine, signifies an alloy such that the proportion of the weight of pure gold to that of the whole weight, is as 22 to 24; or such that it contains 22 parts by weight of pure gold, and 2 parts of some inferior metal.

French System of Weights.—The French denominations of weight occur so frequently in works connected with the physical sciences, that it is convenient to be acquainted with their values. The unit of weight is the *gramme*, which is the weight of the 100th part of a cubic metre of distilled water at the temperature of melting ice. A gramme is equal to 15·434 troy grains; whence the following comparative table of French with troy weight:—

		grammes.		Troy grains.
Milligramme	=	·001	=	·01543
Centigramme	=	·01	=	·15434
Decigramme	=	·1	=	1·5434
		grammes.		Troy grains.
Gramme	=	1	=	15·434
Decagramme	=	10	=	154·34
Hectogramme	=	100	=	1543·4
Kilogramme	=	1000	=	15434
Myriagramme	=	10000	=	154340

The kilogramme is equal to 2 lbs. 3 oz. or 4·428 drams avoirdupois weight. In the *Système Usuel* the standards are the same as the above, but the denominations are those which were anciently in use. It was found impossible to introduce the new terms. The divisions are binary. Half the kilogramme forms the *livre usuel*, which is divided into halves, quarters, eighths, &c., down to the *gros*, which is the eighth of the *once*, or the 1-128th of the *livre*.—(See *Measure*.)

Hectare	=	10000 sq. metres.
Are	=	100
Centiare	=	1
Kilolitre	=	1000 litres.
Hectolitre	=	100
Decalitre	=	10
Litre	=	1
Decilitre	=	0·1
Centilitre	=	0·01

	English foot.
Russian foot	= 1
Paris foot	= 1·065765
Prussian and Danish foot	= 1·029722
Bavarian foot	= 0·957561
Hanoverian foot	= 0·958333
Saxon foot	= 0·929118
Austrian foot	= 1·037128*

* See *Weight*.

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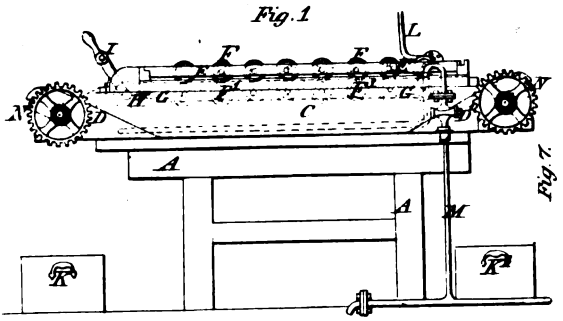
Plate I

Wallerand's impd machy for dyeing.

Fig. 1



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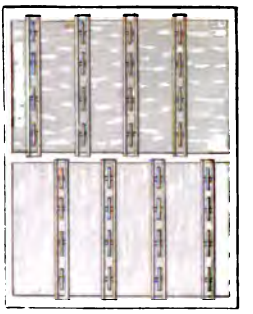
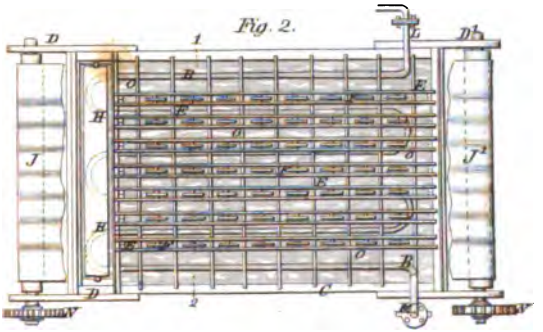


Fig. 2.



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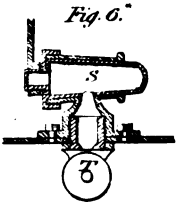


Fig. 4.

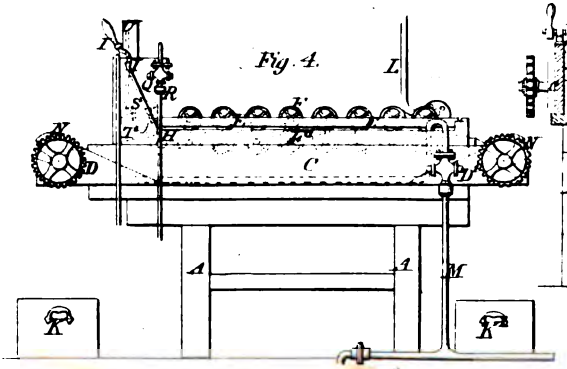


Fig. 3

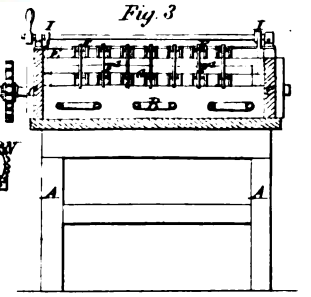


Fig. 5.

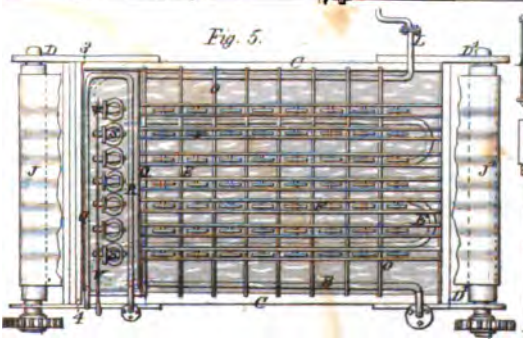
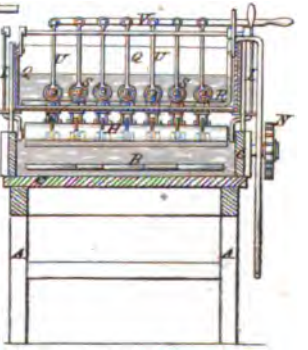
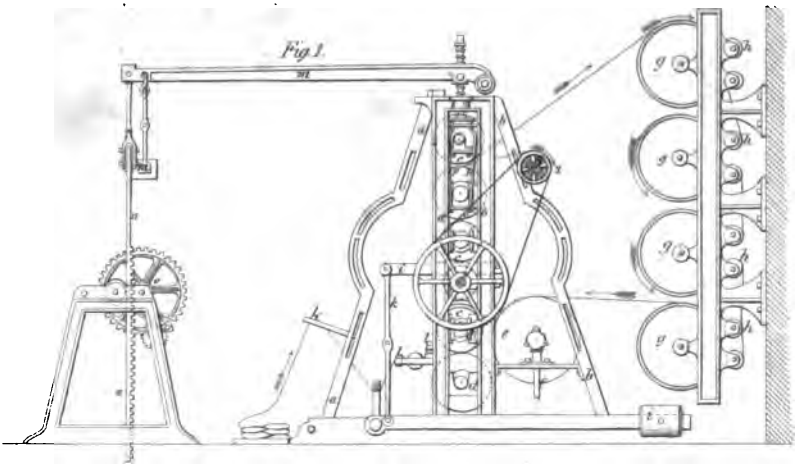
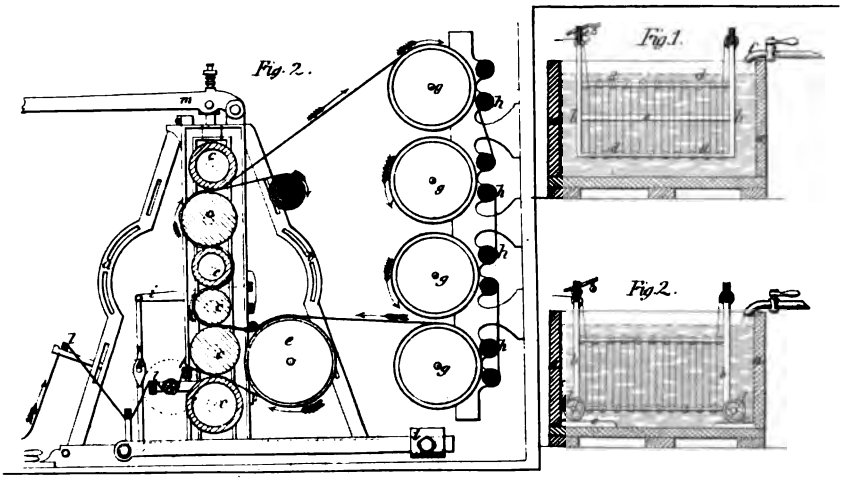


Fig. 6.



Unsworth's impts in drying and finishing woven goods.





Teese's improvements in dyeing &c.

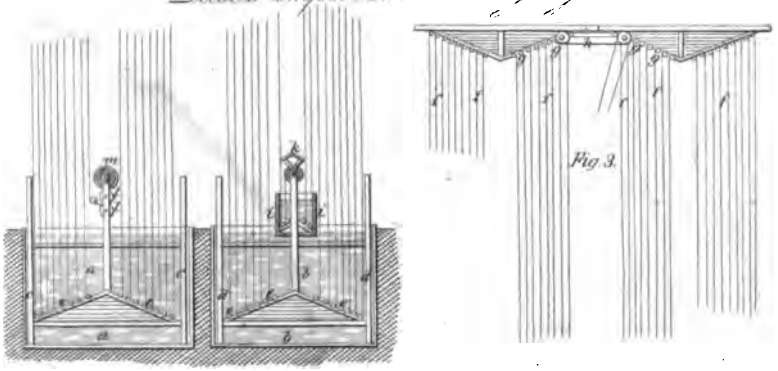
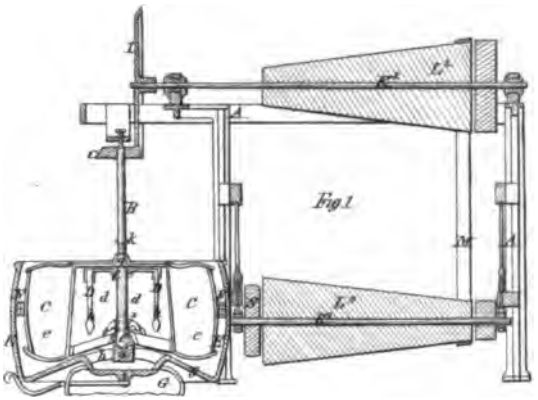
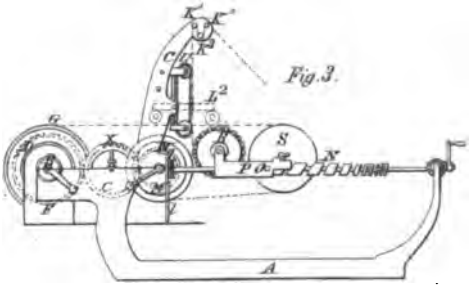
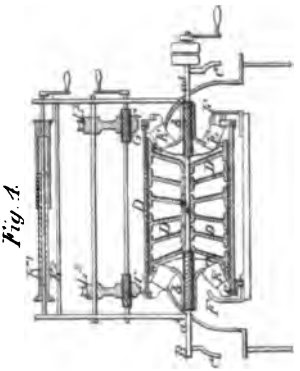


Plate III.

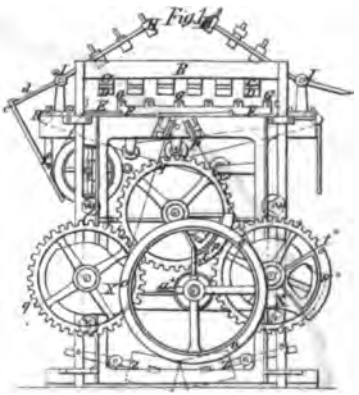
Keeley & Alliott's imp.ts in drying cloth, &c.

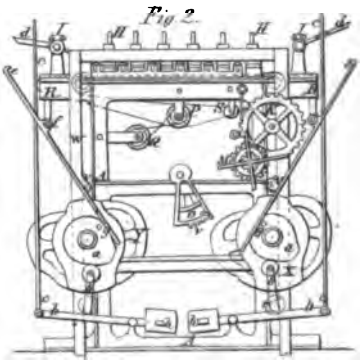






Applegarth's Printing Machinery.





Continued from Plate III.

Fig. 3.

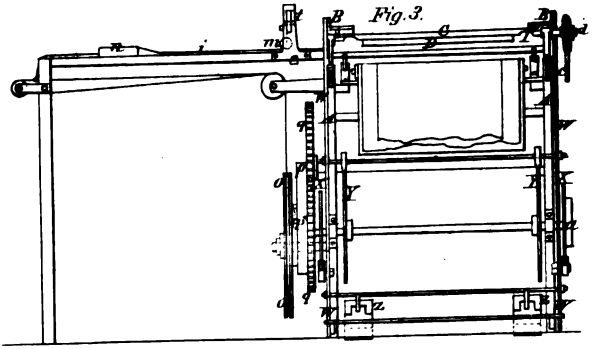


Fig. 5.

Fig. 6.

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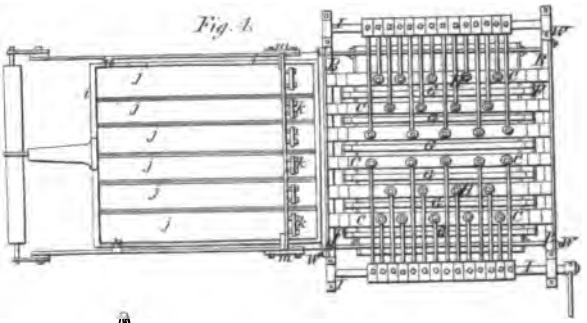

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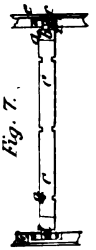
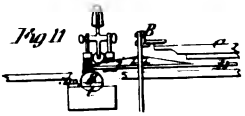


Fig 11



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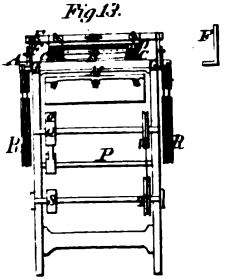
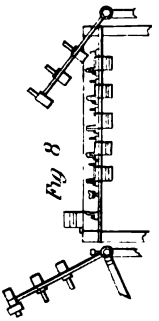


Fig 8



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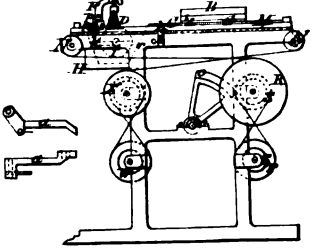

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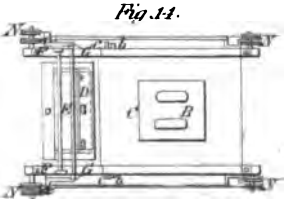

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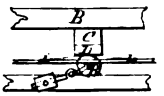

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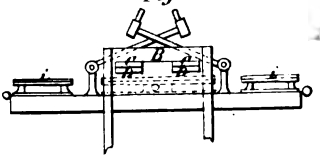


Fig 10.

Plate. V.

Sandifords Improvements in Block Printing.

Fig. 1.

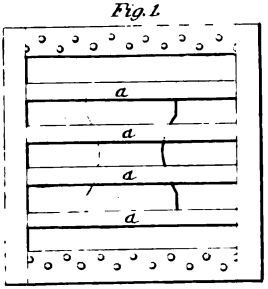


Fig 2.

Fig. 3.

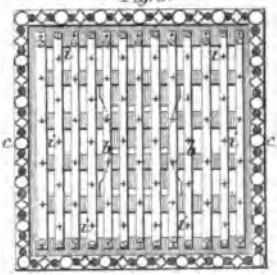
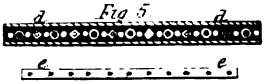


Fig. 5



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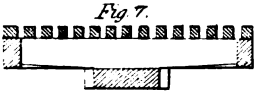

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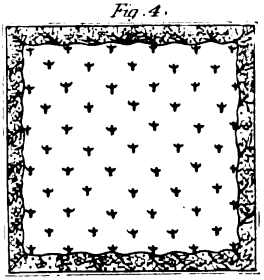

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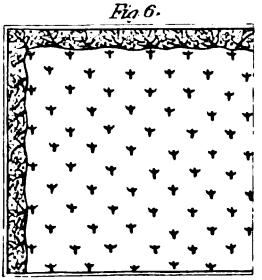

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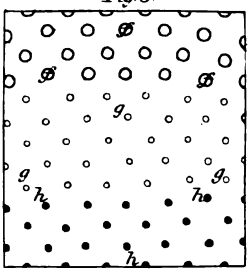

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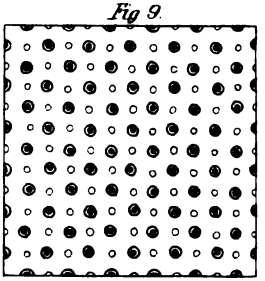
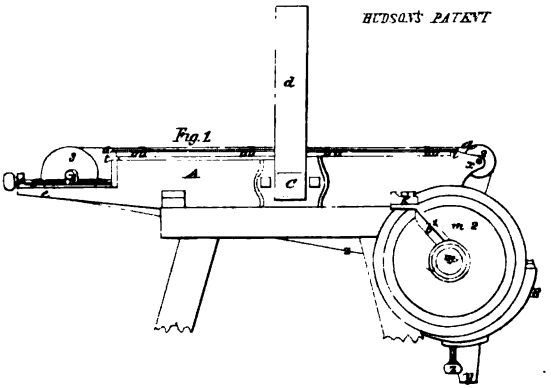


Plate VI

HUDSON'S PATENT

Fig. 1



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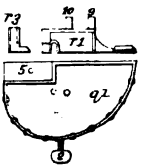

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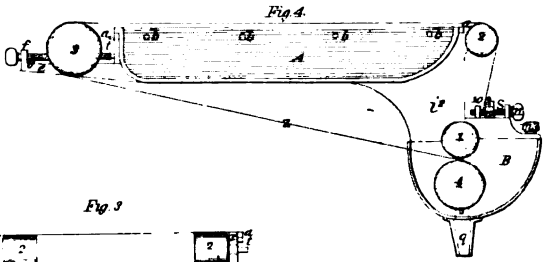
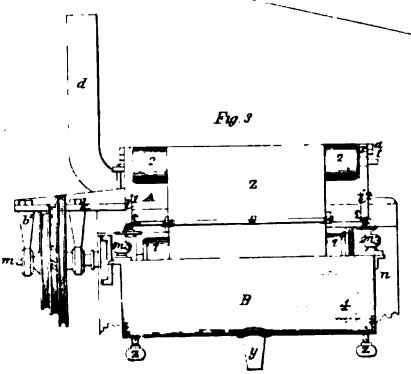


Fig. 3



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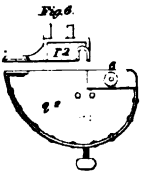


Fig. 2.

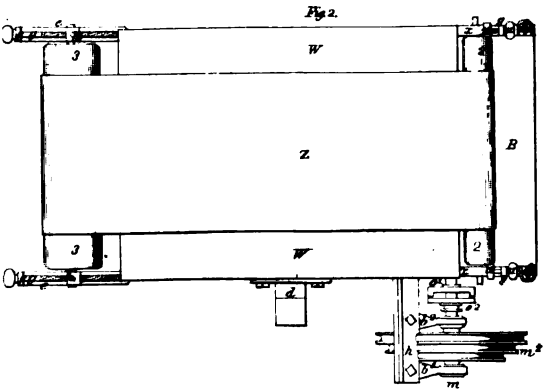
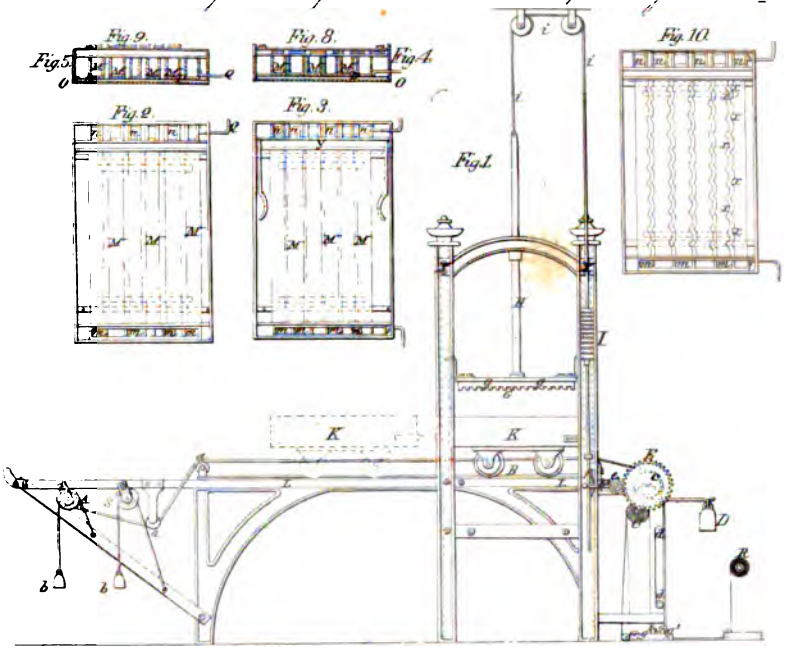
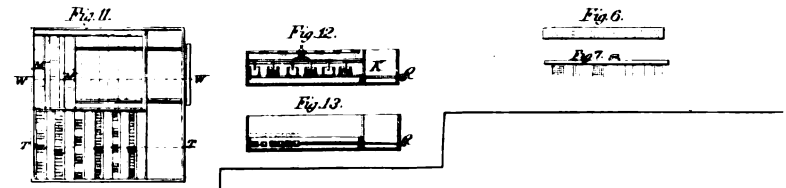


Fig. 7.

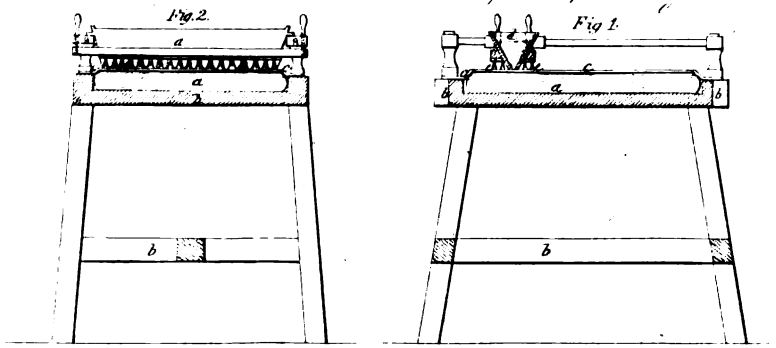
Plate VII.

Hampsons improvements in block printing.





Mc Intosh's impts in printing.



Cullen's improvements in printing calicoes.

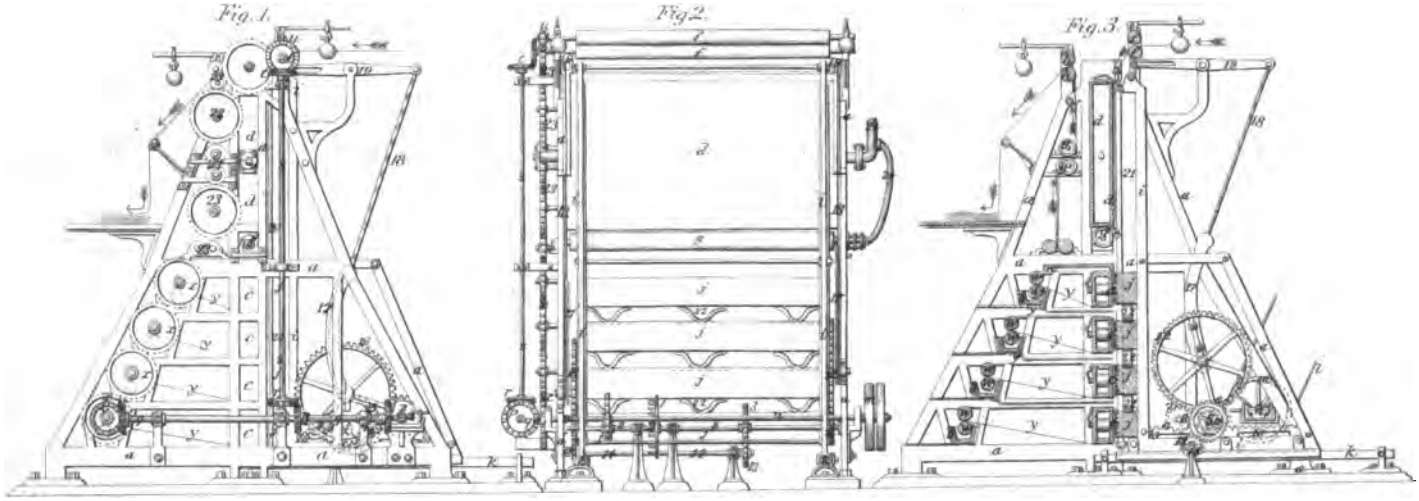


Plate IX.

Woods impts in printing

Fig. 1.

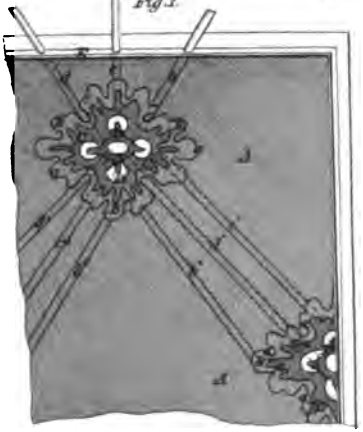
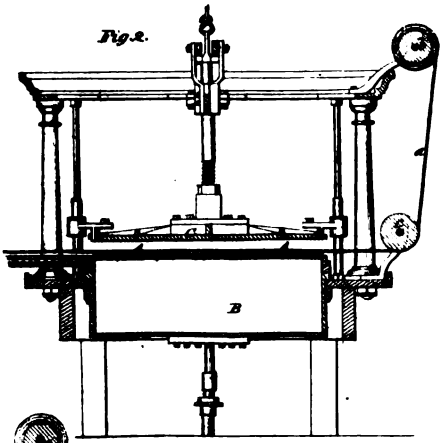


Fig. 4.

Fig. 3

Fig. 2.



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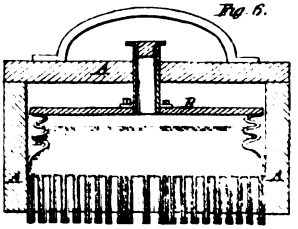

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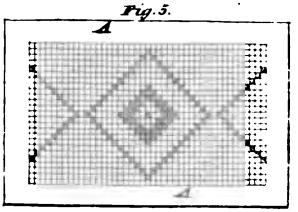


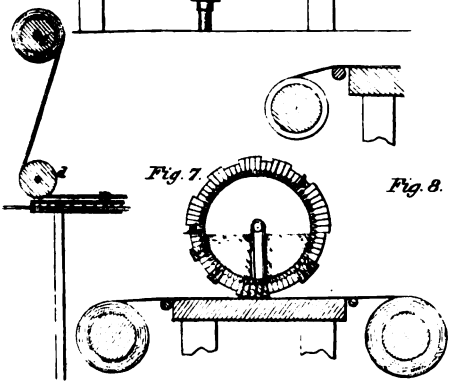


Fig. 7.

Fig. 8.

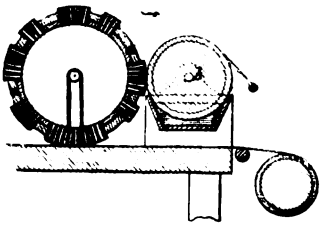
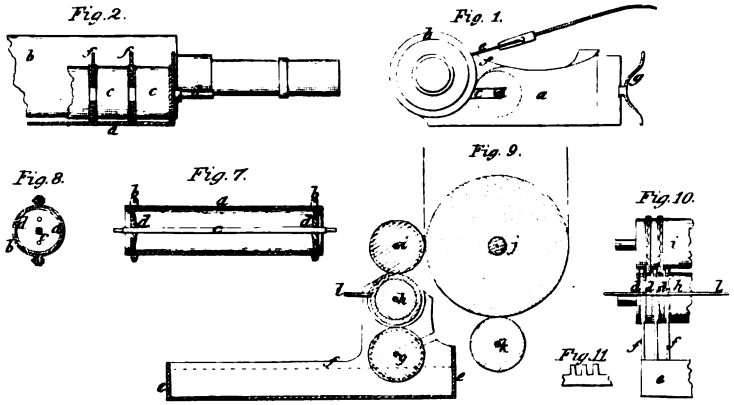
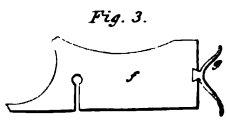
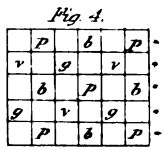


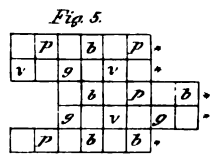
Plate X.

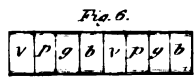
Beard's imp.ts in calico printing

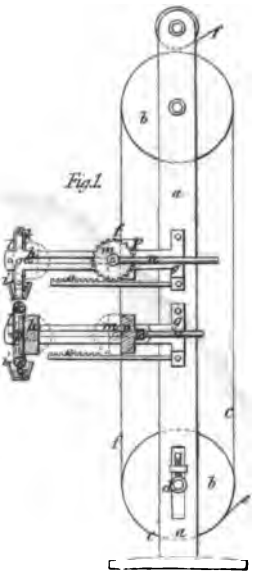




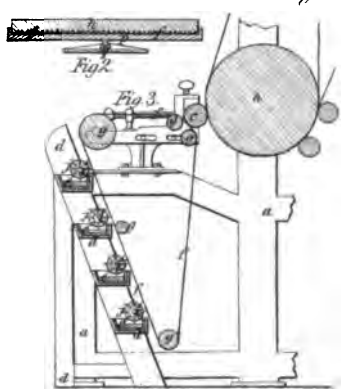








Leese's imp.ts in calico printing.



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Very respectfully yours,
THEO. FRELINGHUYSEN.

Ashland, June, 1846.

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I am, with high respect,
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